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PATHOLOGY OF THE ANOMALIES FOUND IN KNEE JOINTS

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THE patella has been a controversial subject of study by students of anatomy and embryology, and has figured prominently in many discussions concerning phylogenetic development and significance in the light of comparative anatomy. It has been abnegated by one school of writers as a structure which is slowly erasing itself as an essential integral part of the human skeletal framework and as a bone which impairs the performance of the quadriceps extensor apparatus. As a matter of clinical fact, some rather convincing findings have been presented to substantiate this quasi-condemnation of the patella. There is the other school of rather vehement proponents for the patella. They insist that not only is it essential, but that without it, the lower extremity loses its optimum muscular and mechanical efficiency. The truth must lie somewhere in between.

On closer inspection of the apparently conflicting data submitted by both sides, it seems quite clear that the opinions expressed concern two entirely different phases of the development of the patella; that is, the embryological phase of development as compared with the postnatal and functional phase. Walmsley,[41] Carey,[9] Bruce and Walmsley,[6] Haines,[18] de Vriese,[39] and Langer[25] have written excellent and thorough papers concerning various phenomena of the developing patella. There appears to be no doubt that in the embryological development of this bone, the cells which are destined to become the early patellar nucleus are definitely embedded in the substance of the developing quadriceps muscle mass and that the embryonic circumstances of these two structures make their relationship a very close one. Carey,[9] in an excellent paper, studied this problem from a standpoint which he terms "the dynamics of histogenesis." Concerning the specific case of the hind limb bud, he concluded that all embryonic growth is against "resistances" of varying degree, due to a differential rate of growth of the skeletal tissues as compared with the premuscle mesenchymal mass. This causes a stretching of the cytoplasmic fibrils of this mass in the direction of femoral growth. The inception of muscle differentiation is then observed, while at the same time, the femoral rod undergoes compressile and tensile stresses due to resistances to longitudinal growth by the acetabulum, proximally, and the knee structures, distally. Since the femur is flexed on the tibia at about 90°, the patellar tissue comes into direct relationship with the lower end of the femur,

and also undergoes tensile stress from the developing muscle mass, and compressile force from the distal end of the femur. Carey[9] postulates that joint formation will occur in those places where centers of growth oppose each other. A condensation of nuclei, followed by a zone of liquefaction, eventually gives rise to the future joint space. Some contend that the compression lines of condensation of nuclei are due to heredity alone. Carey states that it is purely a mechanical result of opposed growth of contiguous centers. Be that as it may, it is amply shown that a strong interdependence between the patella and its tensile mass of developing quadriceps does exist. As a corollary, one can state that this interdependence is so exact that the slightest alteration in the developing premuscle mesenchymal mass would reflect itself in a commensurate alteration in both the configuration and size of the developing patellar nucleus.

Walmsley[41] studied the problem of quadriceps and patellar interrelationship from the purely anatomical viewpoint. He showed excellent illustrations of the early development of the embryonic patella, and was able to demonstrate an aggregation of rounded cells—forerunner of the patellar nucleus—in the substance of the quadriceps tendon in the 23.4 mm. embryo. This aggregation within the quadriceps network of cells is the earliest yet demonstrated in any embryo. It serves to impress upon one's mind the fact that should anomalous development occur, its inception may very well take place at a much earlier stage than has previously been suspected. The further differentiation of the patellofemoral articular cartilages, the formation of the synovial cavity, the primary appearance of the menisci and the development of crucial ligaments and capsule have all been described quite thoroughly by Langer,[25] and need not be recapitulated here.

It is significant that the early formation of the synovial cavity appears first on the medial side and progresses more rapidly on that side; similarly, the development of the patellofemoral joint space is completed earlier on the medial aspect. After the primitive joint plate has disappeared in the medial patellofemoral space and the synovial cavity has progressively enlarged on that side, the lateral portion of the joint plate remains fused for a comparatively long time before it, too, undergoes the same processes. This developmental priority of the medial side is significant in that its structures might be interpreted as being of more ancient phylogenetic derivation. If so, it might very well facilitate the proper understanding of various abnormal patterns of development which are encountered in the case of the knee joint. This predominance of the medial joint components, including the femoral supracondylar area, is seen in the embryological development of the ox, and other ungulates, in general. It is only in the supracondylar femoral portion, on the lateral side, where the human fetus exhibits a greater anteroposterior measurement. This is essentially a primary human characteristic, predestined for function in the erect position of weight bearing, with the knee in complete extension. It would appear, therefore, that the lateral portions or components of the knee joint exhibit comparatively recent developmental characteristics. In the gorilla, both the femoral condyles are of similar size. It is only in the human that the lateral condyle exhibits a greater anteroposterior prominence.

Since the patella develops in relation to the femoral condyles and passes through a stage of fusion with them, the medial and lateral areas of its articular surfaces are at first approximately equal in size. A change in the relative size begins after the patella has become freed from the femur. It occurs slowly, but at the 192 mm. stage the articular surface of the patella is then divided by a vertical ridge into a larger lateral, and smaller medial area, which are relatively comparable in size to those of the adult. This change in the articular surface allows the patella to conform to the supracondylar surface of the femur (Walmsley).

De Vriese[39] carried out extensive measurements of the patella in various species of animals, as well as various races of the human species, and came to the conclusion that this bone was undergoing phylogenetic regression; that it was not a sesamoid bone but a true bone which, like the fibula, owes its presence in the skeleton to phylogenetic necessity, but that in postnatal life, its conformity in size and shape are entirely dictated by function alone. Walmsley's description of the formation of the primitive patellofemoral articular disc, or joint plate, and its further formation of the patellofemoral joint space, closely follows the same processes of any diarthrodial joint formation. This would appear to lend further anatomical proof to the osseous authenticity of the patella as postulated by de Vriese, who finally concludes that the patella is a typical bone which is on the road to increasing reduction.

Some very interesting experiments were carried out by Niven,[27] whose paper will be discussed in greater detail below. The developing mesenchyme of nine day old avian patellae *was divided into equal portions before chondrification could be microscopically detected.* Tissue culture studies were made and two small discrete masses of cartilage appeared. That portion which was medial to the line of division was always smaller in size than the lateral portion which consistently grew larger. Other than this observation, Niven made no comment, but it would appear to be another indication of the developmental trend of the patella. In further confirmation of this conception of the knee joint, the work of Langer is classical. He describes the independent formation of the medial and lateral portions of the fetal synovial cavity with the medial portion preceding the lateral. He also describes the independent formation of two joint spaces, separated by a septum, extending in the median plane, from the posterior surface of the patella through the entire knee joint, above and below the patella. He then describes the gradual fusion of the two joint spaces. He finally postulates that should the fusion be incomplete, the median septum might persist even to the point of two residual synovial joint spaces.

It is believed that it would be well to recapitulate what has been stated so far:

1. The close anatomical relationship between the patella and quadriceps muscle mass has been demonstrated (Walmsley and others).
2. The important dynamic interdependence of the developing patella and quadriceps muscle has been clearly shown experimentally (Carey).
3. The priority of development of the medial components of the knee joint has been embryologically substantiated (Langer; Walmsley).
4. The patellar mesenchymal cell mass, if divided and cultured *in vitro*, will show a smaller medial area of chondrification and a larger lateral area of similar chondrification, during their independent, though self-limited, period of tissue culture growth (Niven).
5. The prominence of the lateral femoral supracondylar area in the human fetus, as a human characteristic, is demonstrated.
6. The embryonic patella develops a larger lateral and smaller medial articular surface.
7. The entire patella is undergoing a slow and gradual development erasure (de Vriese).

Certain thoughts become crystallized in the reader's mind. The uppermost is that the knee joint is undergoing alterations in all its components. This change is dictated by the fact that only the human who walks in the erect posture also maintains his knees in full extension and is exhibiting itself as a hypoplasia or aplasia in the medial joint structures and as an accessory growth in the lateral aspect of the patella and knee joint.

Thus far, an attempt has been made to illustrate the mutual relationship and strong interdependence between the patella and the quadriceps muscle. The work of Niven, in her successful attempt to culture

individual avian patellae in proper isolation from the remainder of the embryonic limb, would at first glance appear to refute all this. However, Niven was only successful in experiments with the nine day old embryos. The seven to eight day old embryos did not yield similar results. In none of the cultures did articular surfaces develop, and in all of them, the life of the culture was abbreviated, and areas of necrosis began to appear. The reason for the success in the cultures from the nine day old embryos can be attributed to the fact that only at that late date had cell differentiation progressed far enough to permit a period of independent cellular differentiation into cartilage to take place in the culture. Furthermore, this growth was only possible through the impetus of its own cellular activity which finally expended itself, due to lack of the proper environmental stimulus. It does not prove the complete independence of the patella, during differential growth.

CASE REPORT

Case 1. This is the case of a young man, aged twenty-four, who presented himself with complaints of pain related to both knee joints. These complaints had been present "all his life," and had troubled him in one manner or another. He definitely remembers that at the age of about thirteen his knees felt weak and gave way whenever he played strenuous games such as football. His "knee caps would slide sideways" on occasions. The remainder of his personal history is negative. He recalls that his mother once "hurt" her knee, and since then she has had trouble somewhat similar to his, but in the left knee only. Prompted by a justifiable curiosity, he made a comparison of his knees with other members of the family, composed of one brother and two sisters. Their knees were normal as far as he could determine. However, he did establish the fact that his sister's child, aged thirteen, had "split" thumb nails; also his brother, aged thirty, had similar "split" thumb nails. He stated that his thumb nails have never grown, so that they never needed a manicure. Similarly, the nails on both fifth toes exhibited the same condition.

Fig. 1. Case 1.

Examination. The patient was first examined completely unclothed. His posture, state of nutrition, musculature, and general condition were satisfactory. There was no apparent deformity, other than that to be described about the knees. In the sitting position, and viewed from one side, one immediately noticed the absence of the usual patellar prominence. The range of motion in the knee joints was smooth, complete, and painless; no effusion was present; there was no ligamentous relaxation about the knee joints; the quadriceps apparatus was somewhat lax, so that the patella could be pushed laterally as far as the anterior prominence of the lateral femoral condyle, but could not be pushed laterally farther than this. The musculature of the quadriceps was closely examined and the absence of a major portion of the lower third of the vastus medialis was observed. Instead, there remained a rather broad, flat, sheath-like aponeurotic structure which, together with the overlying skin, was the only thickness which lay between the examiner's finger and the subjacent synovial lining.

The patella was found to be exceptionally small and situated well in the lateral half of the knee joint area. The missing portion of the patella corresponded roughly to that area of the bone which normally would have provided tendinous anchorage for the vastus medialis. The latter was also missing to a large extent.

The thumb nails were found to be thin and almost transparent. Other than this, nothing of note could be found.

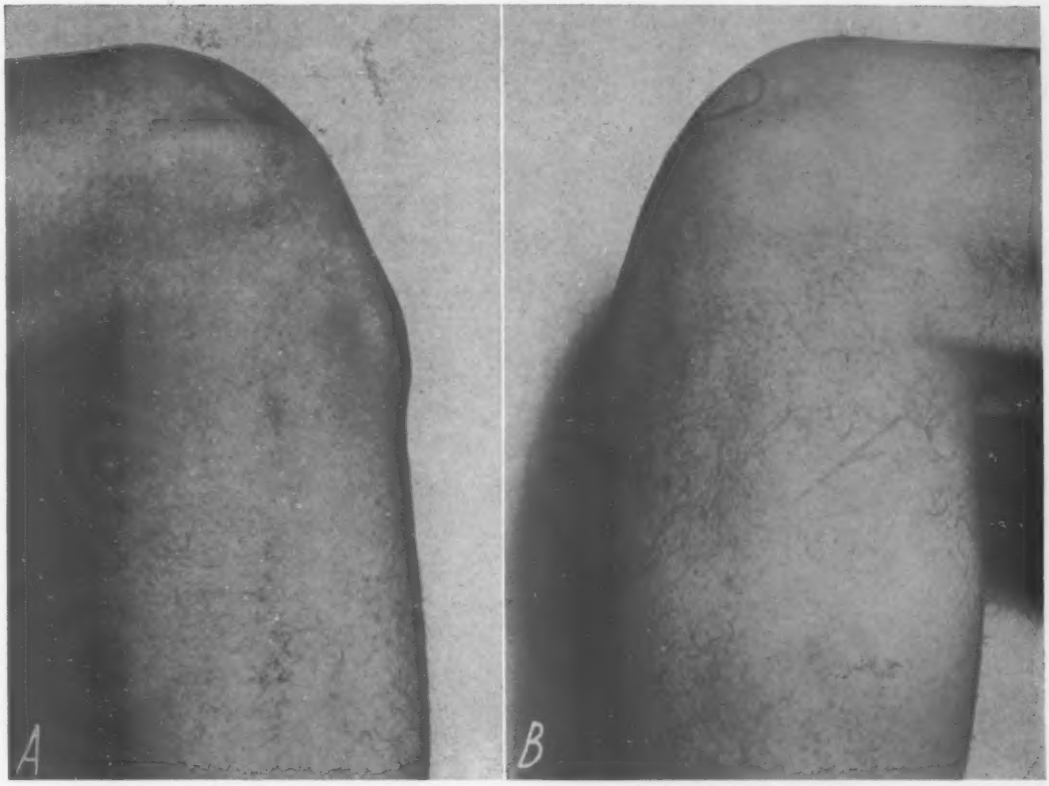


Fig. 2. Case 1. *A* and *B*, the level below which the vastus internus is almost absent bilaterally. Note the flattening due to the absence of the patellar prominence. This renders the tibial tubercle rather prominent in comparison.

Roentgen Findings. Various joints and long bones were examined roentgenologically. The wrists exhibited an apparent fusion between the os magnum and the articulating metacarpal bone, bilaterally. On the right wrist, one found a small ossicle on the dorsum of the hand, overlying the carpal lunate and triquetral bones, and apparently articulating with them very much like the pisiform articulates with the triquetral bone on the palmar surface.

Detailed roentgenograms and pneumarthrograms were made of both knee joints. These yielded some rather interesting findings.

In the anteroposterior view, one can clearly visualize the synovial cavity in both knees. The medial compartment is seen to be smaller and underdeveloped compared with the lateral (Fig. 4, *A–B*). There is also visualized a vertical septum which separates these two unequal compartments. It extends downward and is seen to end in the infrapatellar fat pad, in the intercondylar area.

In the lateral view, clearer detail of this septation is possible. It is incomplete, and allows intercommunication between the two compartments. The edge of this septum is falciform, and faces toward the center of the joint space. In one of the lateral views, its posterior end anchors itself to a small projection just anterior to the anterior tibial spine. This projec-

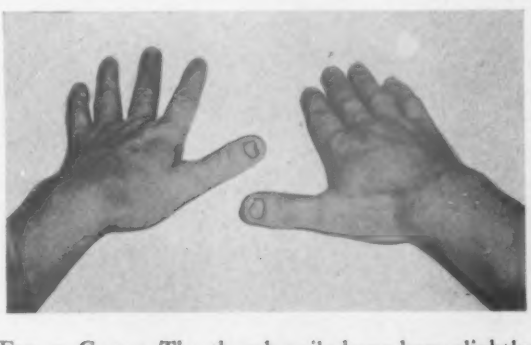


Fig. 3. Case 1. The thumb nails have been slightly retouched to better delineate their outlines.

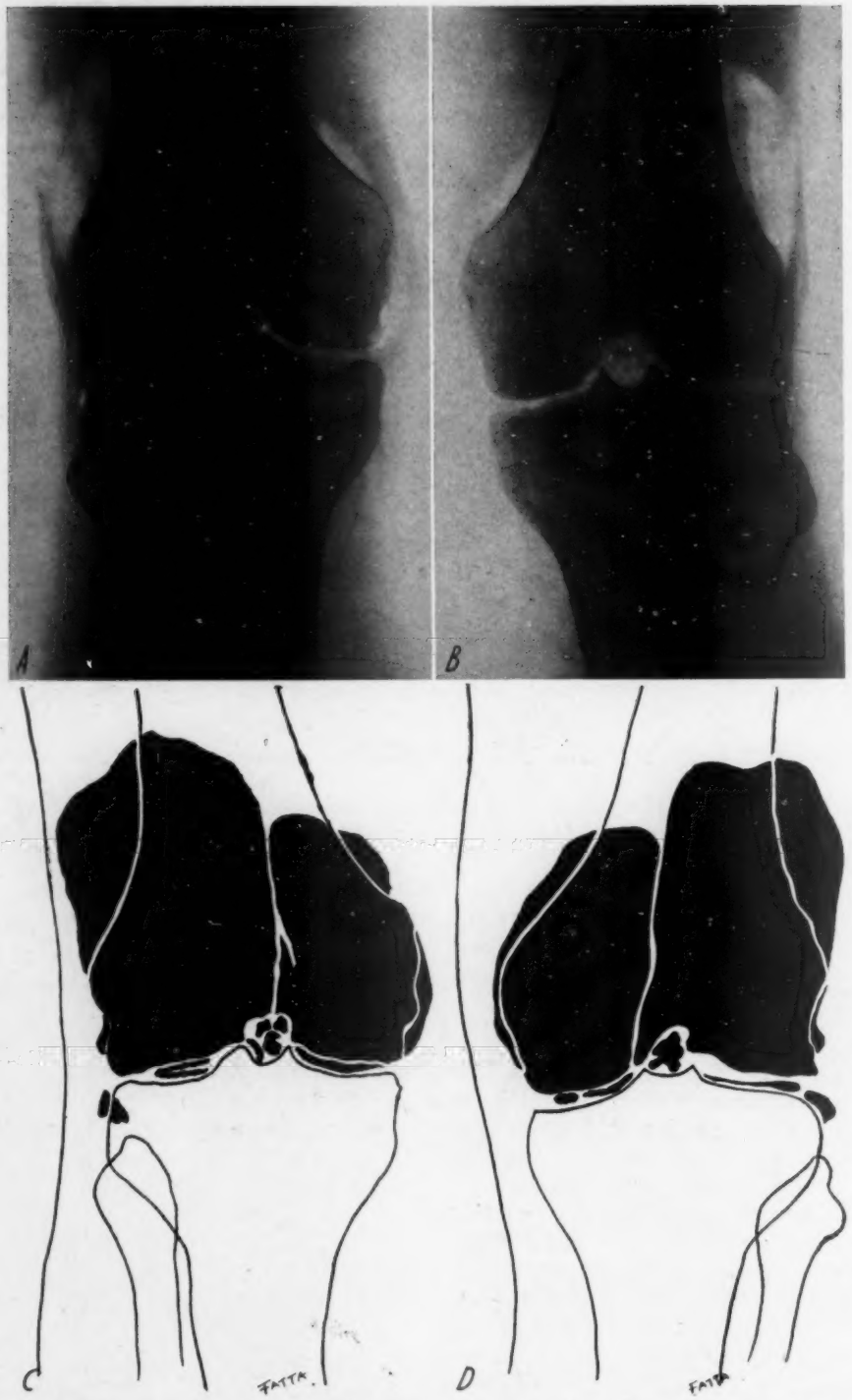
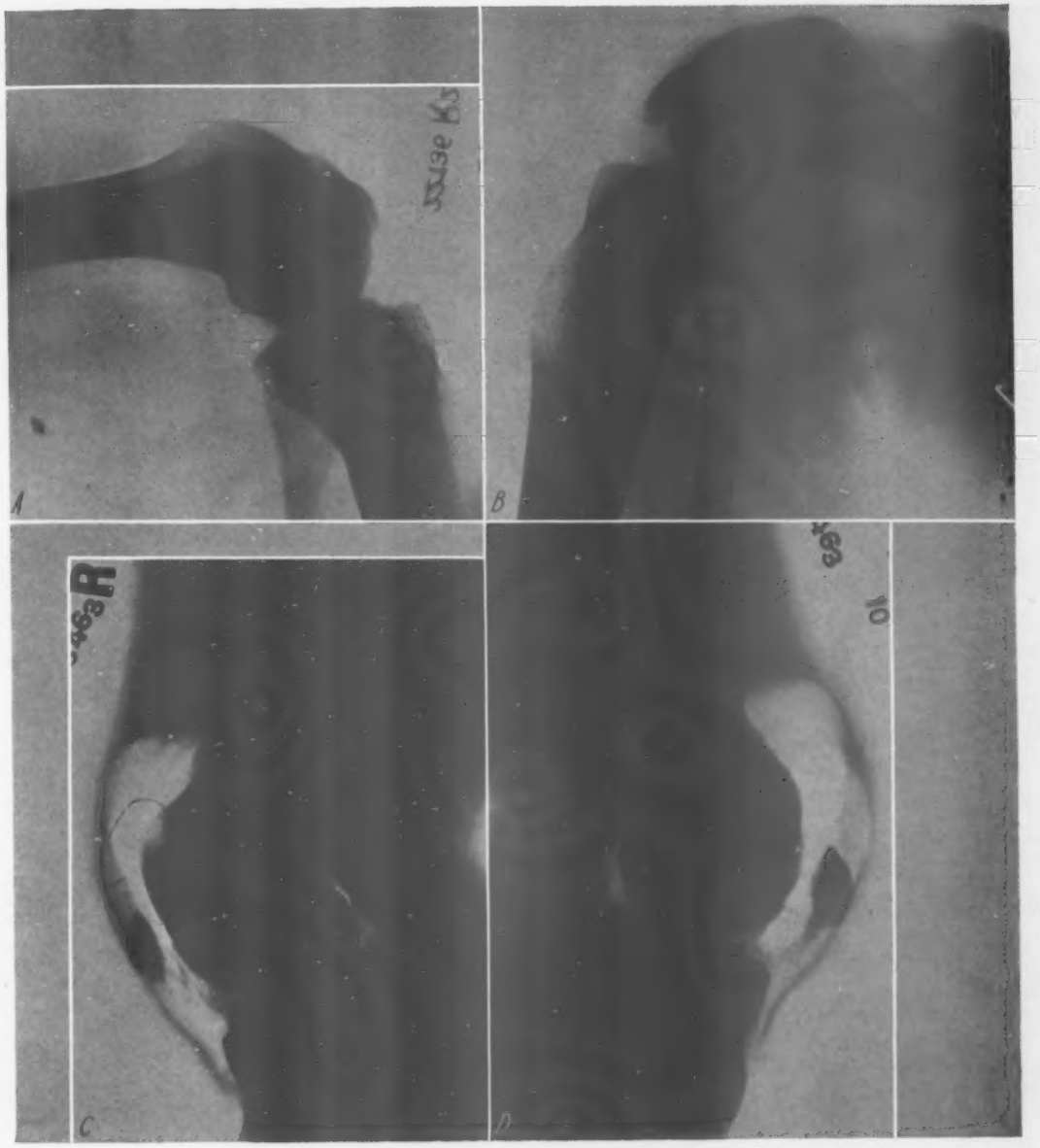


Fig. 4, *A–D.* Case 1. Pneumarthrograms and drawings of pneumarthrograms of the knees. Note the smaller underdeveloped medial synovial compartment. Note also the vertical septation which extends downward toward the intercondyloid notch. The septation is complete in the anteroposterior view. It is seen to be incomplete in the lateral view. Vertical septation with intercommunication between the compartments of the knee joint is not uncommonly seen in the horse.



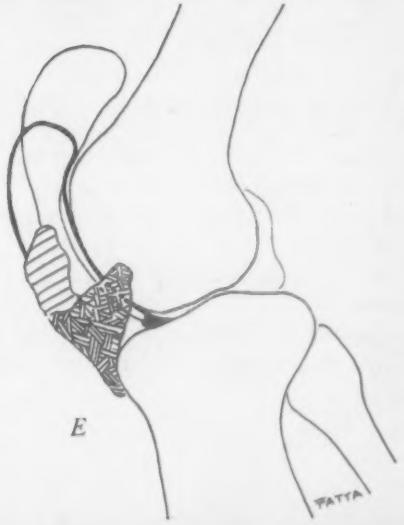


Fig. 5, *A–E*. Case 1. Lateral views of the pneumarthrogram, outlining the boundaries of the incomplete septation. Note how the latter finds attachment posteriorly to a projection just anterior to the anterior tibial spine. This projection is not visualized without air as a contrast medium. Therefore it is nonosseous in character. Note also that the infrapatellar fat pad, which is the remnant of the embryonic median septum, is within normal limits of shape and size.

tion was not visualized without air as a contrast medium, and therefore must be of a non-osseous nature, probably cartilage or fibrous tissue (Fig. 5, *D–E*).

It was necessary to deflate the knees to allow sufficient flexion in order to obtain satisfactory vertical views (Fig. 8, *A–F*). It is amazing how much soft tissue detail can be brought out by this technique. Medial to the osseous patella, and in an identical position, could be found a soft tissue structure which closely resembles the bony patella in size and outline. If one were to draw a line about these two structures, the result would be the outline of a practically normal patella. The pneumarthrograms seem to indicate that the medial portion of the patella never went into differentiation from the rounded cell state (during the 23.4–30 mm. stage) and matured into ordinary fibrous tissue, but retained its outline and size to a great extent.

Langer[25] has already mentioned the possibility of the persistence of median septation in the knee joint. However, no instance has been found in the literature resembling the findings reported above.

Vertical septation in the knee joint, with intercommunication between the compartments, is not uncommonly found in the horse.

A search has been made of the literature for descriptions of this particular anomaly or rather, combination of anomalies, and it was found to be not uncommon. In none of the papers, however, was a description of the thigh musculature given, except in one case by Susman,[35] who mentioned "the obvious wasting of the thigh muscles." An opportunity for a study of the interior of

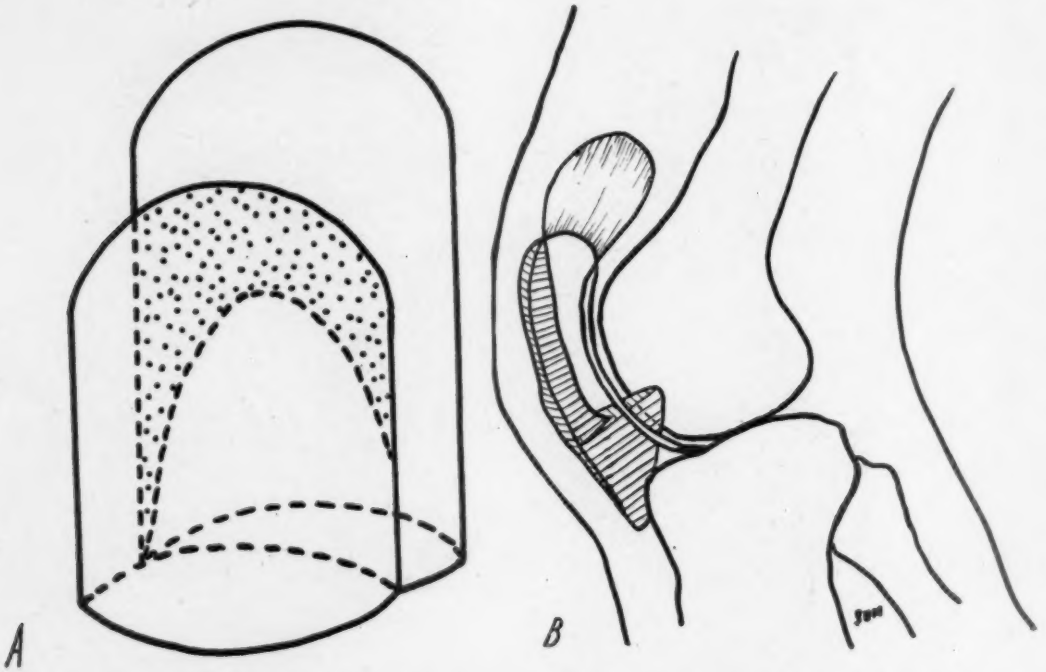


Fig. 6*A*. Diagrammatic illustration of the intercommunication between the smaller medial and larger lateral compartments of the synovial cavity through an incomplete partition or septum. The defect in the septum is bordered by a rather sharp curved falciform edge.

Fig. 6*B*. This drawing represents a reconstruction of the appearance of the vertical septation. Anteriorly, close to the mid-level of the patella, it is roughly triangular in shape. It then sweeps upward over the anterior wall, rapidly tapering off, so that as it reaches the spaces between the domes of the two compartments, it is but a mere edge. It then separates the two compartments by a broad fan-like septum. As it reaches the posterior wall, it again tapers considerably and finally becomes attached to a projection of non-osseous architecture just anterior to the anterior tibial spine. The septum always presents a falciform edge facing towards the interior of the knee joint.

the anomalous knee joints by the use of air injected into the synovial cavity has presented itself—the so-called pneumarthrogram.

Genealogical studies were made by Aschner,[2] Turner,[38] Malkin,[26] and Susman.[35] Their case histories appear to establish the fact that the anomalies were transmitted by the affected female member of the family in the vast majority of cases. In Susman's series, it appears to have been transmitted only by the maternal parent. However, the affected female does not always transmit it to her offspring. Many members of these families exhibited fingernail changes in addition. These families are found in the United States, France, Austria, and Australia.

Rubin,[29] Spellisy,[34] and Cadilhac[8] reported a number of cases with completely absent patellae. Cadilhac's painstaking report of over 80 cases is a classic of detail and bibliographical research. His compilation included all the reported cases which he could find in the literature up to the date of his thesis (1907). In his clinical descriptions, however, many of the cases exhibited other congenital anomalies about the knee joint, as well as dislocation and deformity in the ankle or hip joints. An-

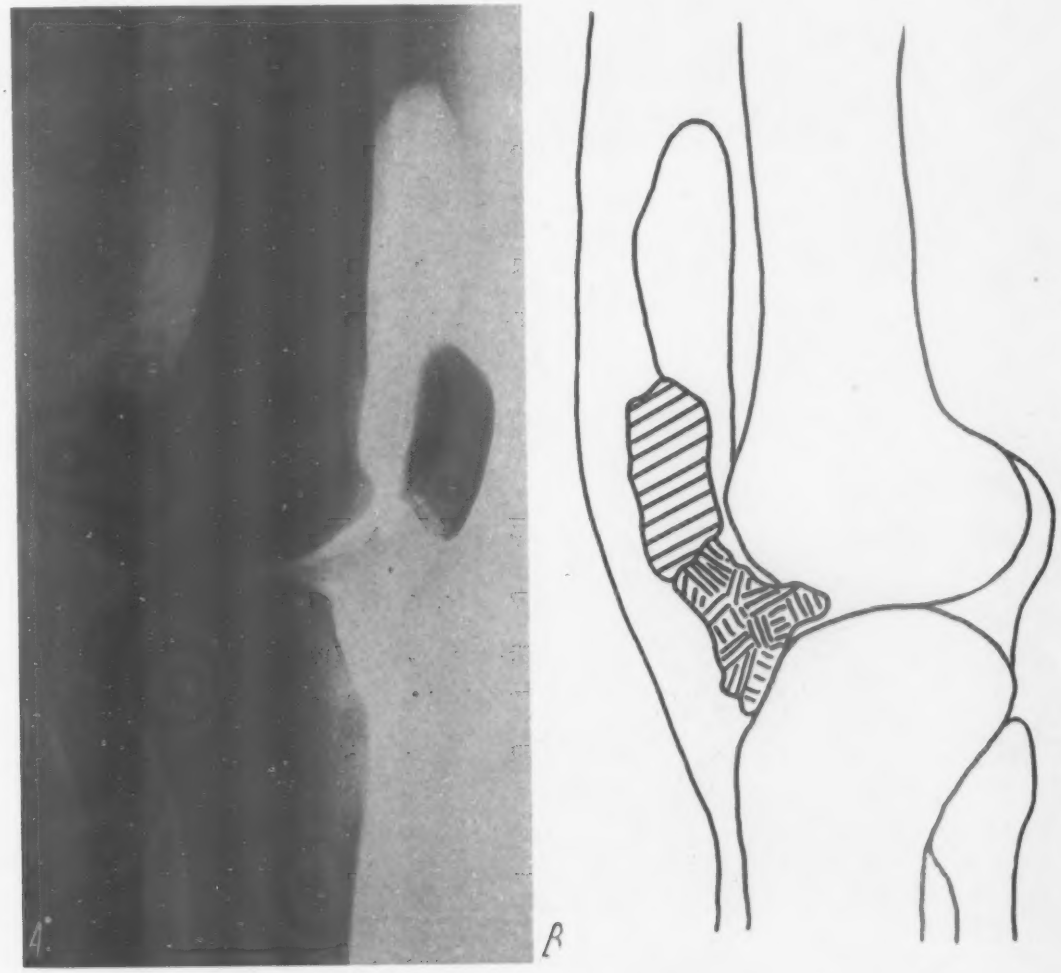


Fig. 7, *A* and *B*. Lateral view and drawing of the normal pneumarthrogram. Note the outline of the synovial cavity and suprapatellar pouch. Note also the size and shape of the infrapatellar fat pad.

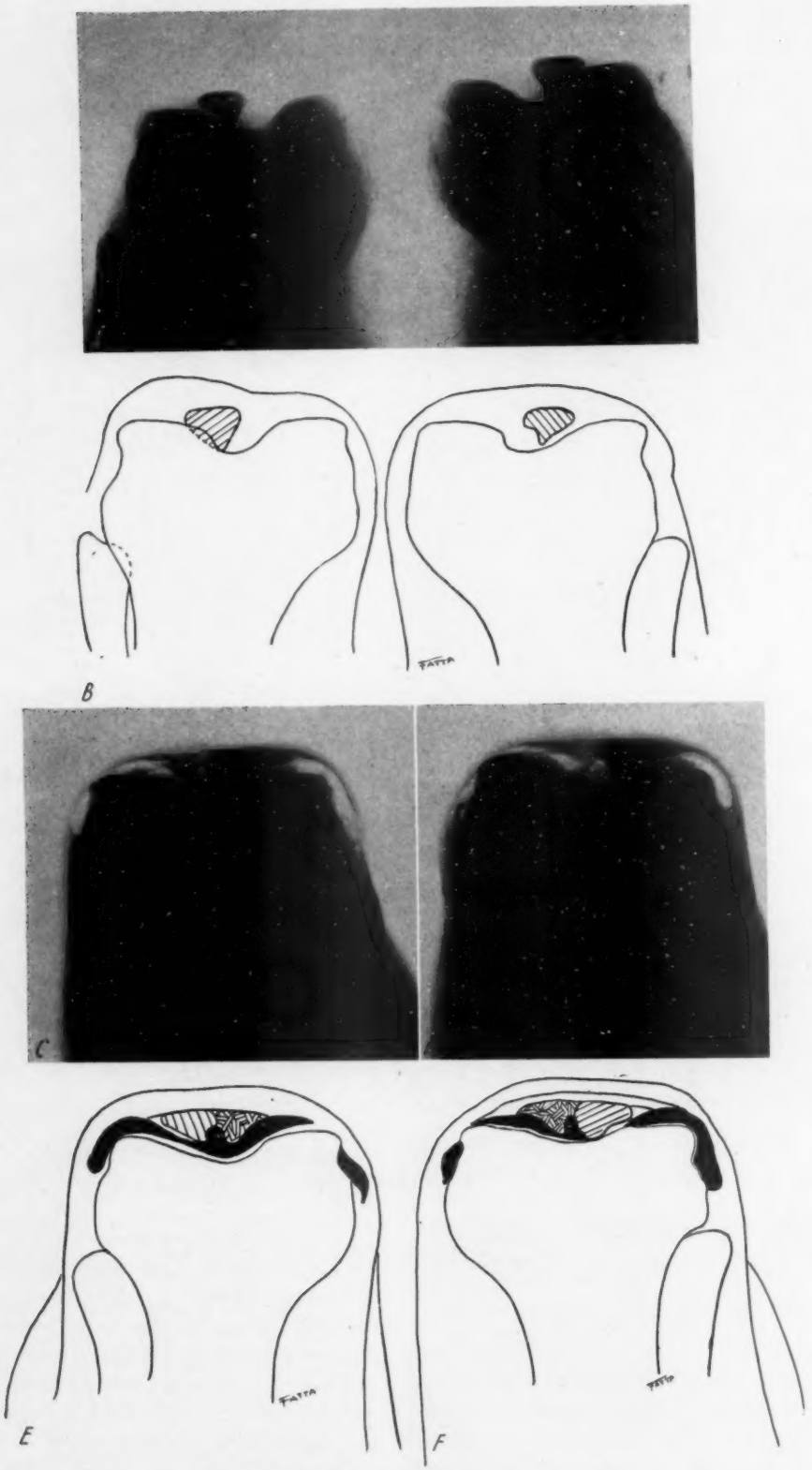


Fig. 8. *A–F.* See opposite page for legend.

other large group of his cases exhibited hyperextension deformity, or genu recurvatum. The only illustration found in Cadilhac's paper shows a congenital dislocation of the knee with the femur displaced posteriorly, producing a marked genu recurvatum. I do not feel that these should be included in this report as additional examples, similar to the described case, since all Cadilhac's cases were complicated by various additional deformities of a congenital nature. He pointed out that in 16 of his cases the absent patella eventually appeared and could be felt. In his conclusions, he stated that in the vast majority of the cases he noted anomalies of the quadriceps extensor apparatus, the commonest of which was atrophy and absence of muscle tissue. Many of them exhibited faulty insertion of the patellar tendon.

The greatest contribution from his work lies in the fact that once again the close patelloquadriceps relationship is exhibited. As Berkheiser[3] stated " . . . in the human being born with genu recurvatum, the patella fails to develop until the deformity is corrected surgically and natural functional stresses are restored, after which the patella enlarges and develops. . . ."

The question that arises in the study of the pathology in the case described here is whether we are dealing with a patella, or whether it represents an accessory bone center with the patella proper entirely absent. The question is well justified and the answer is not simple. A glance at Figure 9 will show the result of a composite drawing of many tracings of the patella in its usual positional migrations or variations within normal limits. Superimposed on this, one can see the composite drawing of many similar tracings made of accessory centers in the bi-, tri-, and multi-partite patellae which were found in the department of roentgenology. For purposes of discussion, we will designate the composite normal patellar tracing as the patellar area. Similarly, we will designate an accessory patellar area. The relationship of the latter to the former is constant. The accessory patellar area will always be found in the upper and lateral aspect of the patellar area. The same type of tracings were made in order to establish a relationship between the patellar area and the patella in our case described here. The result is seen in Figure 10.

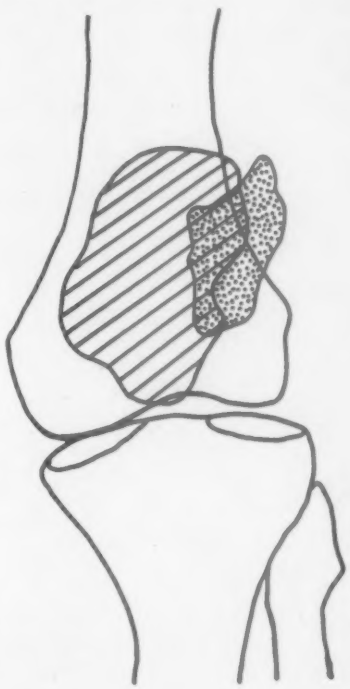


Fig. 9. In this drawing, the stippled area represents the composite variation in positions of accessory patellar centers—the so-called accessory patellar area. It indicates that this area is generally in the upper and outer portion of the patellar area.

Fig. 8, *A* and *B*. Vertical views and drawings to illustrate the close relationship of the patella to the lateral femoral condyles. It rests well within the intercondyloid space.

Fig. 8, *C–F*. It was necessary to partially deflate the knees in order to obtain sufficient flexion for the vertical views. The mass of undifferentiated tissue medial to the patella is clearly outlined. Its shape and size is similar to that of the osseous portion. If one were to draw an imaginary line to encompass both of these structures, the outline would be surprisingly close to that of a normal patella. Compare this with Figure 8, *A* and *B*, where the soft tissue was not visualized without air as a contrast medium.

It seems quite evident that the positional relationship is definitely in the lower and lateral aspect of the patellar area. Furthermore, the smaller area is almost entirely included in the patellar area. Tracings made in the lateral, as well as the vertical planes, tend to further confirm what is now quite evident. Therefore, we can, with a good deal of assurance, assume that the structure seen in Figure 5, *A* and *B*, is true patellar bone.

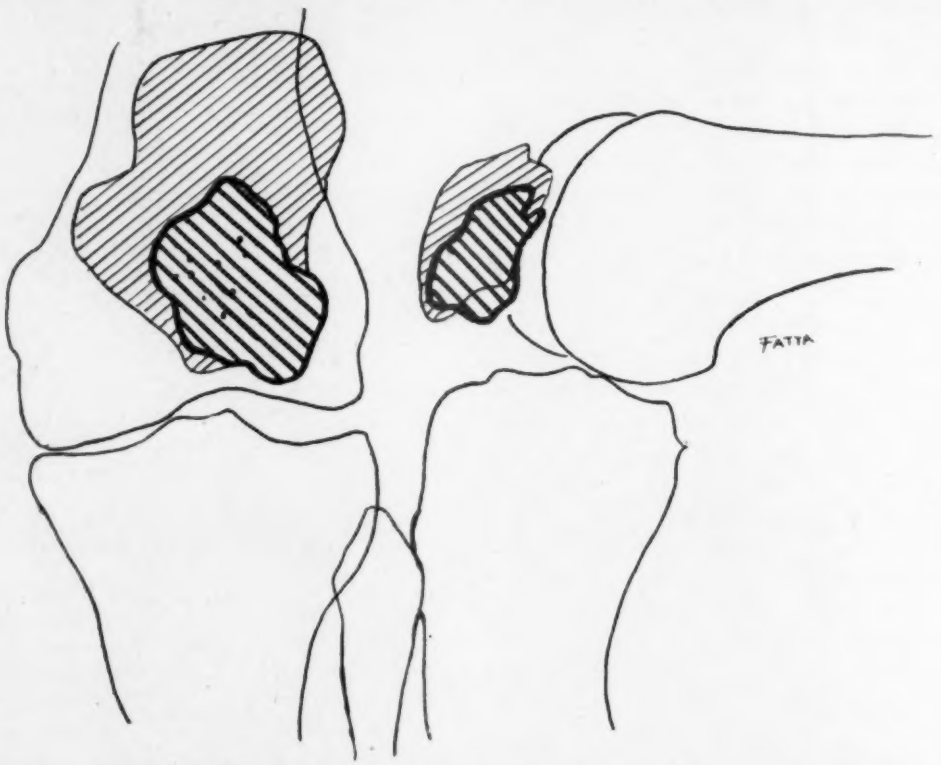


Fig. 10. Composite drawing of a large number of positional variations of the normal patella. Over this, in both the anteroposterior and lateral views, was superimposed a composite drawing of the relative position of the anomalous patella in relation to each individual normal tracing. It falls almost entirely into the true patellar area in both views. This would tend to reinforce the impression that we are dealing with a true patella, and not with an accessory center as illustrated in Figure 9.

The partial absence of the vastus internus should be interpreted as being a significant feature. A strong impression prevails that the "wasting of muscle," mentioned by Susman, probably represents a situation which obtained in many of the cases which were reported in the past, but were not given sufficient clinical prominence. Stimulated by Carey's work on the dynamics of histogenesis, in the pig embryo, the feeling persists that we are not dealing with a complete, small, hypoplastic patella. It is in reality a case of full development of the lateral portion of the bone associated with no development of the medial portion—a hemiplasia, as it were, if one may coin a word to describe the situation. It can further be postulated that the absence of development in a portion of the patella can be directly traced to the absence of a portion of the quadriceps muscle group, resulting in a proportionate loss of tensile stress on the developing condensation of precartilaginous patellar round cells, in the embryo. This loss of tensile influence on a portion of the embryonic patellar nucleus actuated an arrest of differential growth in an equivalent area of precartilaginous patella. In its lateral portion, the

embryonic cells developed in the usual manner. In the medial portion, on the other hand, the same embryonic cells were "short-circuited" into mature fibrous tissue formation. This produced a fibrous tissue mass which has retained its outline to a great extent; to what extent, can be determined by the pneumarthrograms described in Figure 8, *A-E*. It would be interesting to know at what stage in fetal development the above arrest occurred.

To quote Walmsley,[41] "The patella is seen to be developed in relation to the lower surface and the lower part of the anterior surface of the femur, and though there is no direct contact of the patella and femur, the lower part of the patellar surface of the femur has taken form already in the 23.4 mm. embryo."

Since the femoral condyles are already well formed in the 23.4 mm. embryo, and early beginning transformation of the patellar cells into embryonic cartilage does not occur before the 30 mm. stage, it is assumed that the defects as noted in our case were laid down in the abnormal anlage, or failed to differentiate somewhere in this segment of the developmental circle (that is, 23.4–30 mm.). This conception is also enhanced by the fact that during this stage muscle differentiation progresses. Therefore, the primary cause for the lack of development of the quadriceps, with which the patella is closely bound in its embryonic life, is due to the lack of differentiation of the premuscle mass from its rounded cell stage. Later, in the 32–55 mm. embryo, the joint plate of the patellofemoral joint is seen and the beginning synovial cavity formation is also seen in the 35 mm. embryo. It is not difficult to understand why the formation of the suprapatellar pouch, as well as the synovial cavities (particularly the medial cavity), should be directly influenced by the developmental change just described.

The patellar nucleus develops in the muscle mass; the quadriceps pouch enlarges by extension into this same mesenchymal mass; and the formation of both these joint structures predicates the presence of a normal muscle mass. If the latter is deficient, it necessarily follows that the patella and synovial cavity will also be deficient. It is therefore evident that from the 30 mm. stage onward, the future development of the fetal knee joint (such as in the case of our patient) was already predestined to come to an anomalous end, due to abnormal factors at work, at that early stage.

Fig. 11. A composite drawing of a number of tracings in the vertical view, of bi-, tri-, and multi-partite patellae. The stippled area represents the accessory patellar area. The striped area represents the patellar area. The relationship between the two areas is seen. A glance at Figure 8*B* shows that the patella would fall entirely into the true patellar area.

It becomes apparent that all the roads of investigation and inquiry converge upon the structure which is most pertinent to the problem—the premuscle mesenchymal mass, which is undergoing differentiation into early quadriceps formation. No sooner have we focused our attention upon this structure, than we ask ourselves the next question: Why does this mesenchymal mass fail to differentiate? The answer to this lies bound in the interpretation of that multifarious phenomenon called heredity.

A short consideration of the hereditary factor would not be amiss, and would help to clarify some obscure points. To one who

is not acquainted with the profound secrets locked up in the gene, all this is confusing. After a careful study of some of the literature on this subject, several elementary and well known points seem to stand out boldly above the others. Aschner[2] predicated that the combination of ectodermal (fingernail) and mesodermal (knee joint) abnormalities in the individual described in our case report were due to separate pathologic factors in the genotype. The genotype represents the sum of all potential hereditary factors present in the fertilized ovum. Where do these potential anomalies reside in the fertilized ovum? They are to be found in the genes, which are in turn but portions of the chromosomes. These genes within the same chromosome may be juxtaposed or may be situated at opposite poles of the chromosome. In this manner, they become "linked genes" and may go on, in close association, to development of characteristics, normal or abnormal. Thus, with two closely linked genes, the association of mesodermal and ectodermal anomalies may occur in the same individual. For practical purposes of this study, the anomalies in the case described above were initiated by aberrant or abnormal linked genes, which brought about an aberrant embryological development of the premuscle mesenchymal mass of the quadriceps extensor apparatus. This deprived a portion of the developing patella of the necessary growth stimulus for differentiation. In a general way, the original stimulus for differentiation in embryonic cells is imparted by the fertilized ovum. The capacity for growth differentiation in these cells is actuated by those factors which are inherent in any living cell, but this capacity is necessarily self limited and will entirely cease unless the developmental stimulus is perpetuated by a series of embryonic events which serve to maintain the smooth continuity of this cell differentiation. Each so-called embryonic event gives rise to its successive event with a resultant corresponding change in both the anatomical (Walmsley) and dynamic (Carey) environment, and so on to final completion of the organism. Any interruption in the chain of successive events will produce a concomitant interruption in cell differentiation. If it occurs early, a complete lack of differentiation (aplasia) will occur. If it occurs later, varying degrees of partial differentiation, or hypoplasia, will be found.

SUMMARY

1. A case report of an individual with congenital changes in the knee joint has been presented.

2. The basic pathology has been described as being due to aberrant or pathological linked genes which possess abnormal mesodermal and ectodermal characteristics, respectively. This explained the presence of both ectodermal and mesodermal anomalies in the same individual.

3. The primary developmental aberration due to the pathological gene is manifested by faulty and incomplete differentiation of the premuscle mesenchymal mass which ordinarily is destined to become a portion of the quadriceps extensor apparatus—the vastus internus.

4. This lack of muscular differentiation has initiated a number of secondary developmental changes in the patella, quadriceps pouch and the synovial cavity. All these changes have occurred in the medial portion of the knee joint and have exhibited either hypoplastic or aplastic characteristics.

5. The presence of an incomplete vertical septation in the knee joints has been described and explanation for its presence has been given.

6. The feeling is expressed that the patella which has been described above represents its lateral portion only. An explanation for the absence of its medial portion has been given.

7. The medial portion of the knee joint possesses older phylogenetic structures than its lateral portion. Anomalies in the medial compartment will present themselves in the form of developmental erasure. Anomalies in the lateral portion will present themselves in the form of accessory

growth. It is to be noted that accessory patellar centers are constantly found in the lateral portion.

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ADDENDUM

Since the completion of this paper, I have had the opportunity to examine another similar case.

Case ii. A man, aged twenty-six, came to the orthopedic clinic complaining of pain in the left elbow and both knees. On examination he was found to have unusually small patellae which were displaced laterally bilaterally. The

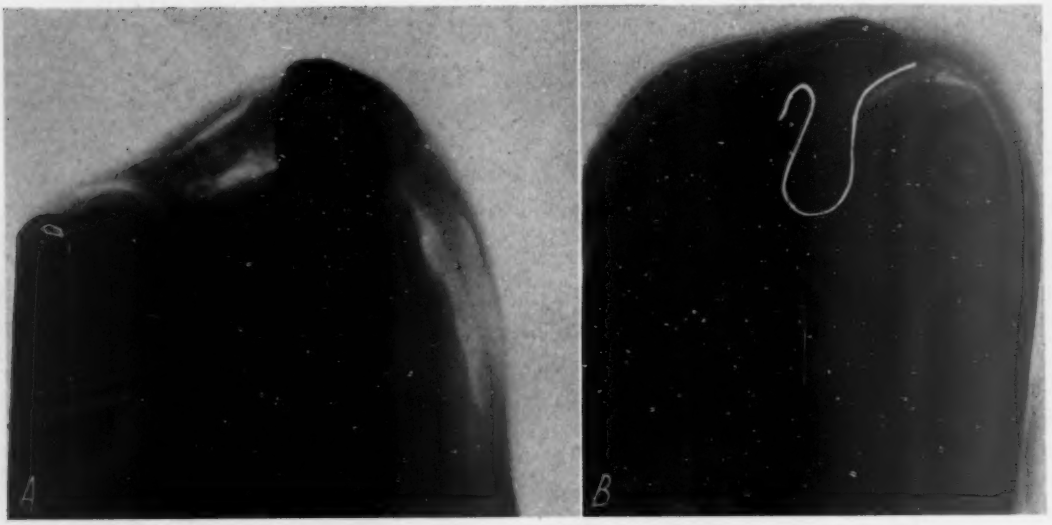

Fig. 12. Case II. *A*, vertical pneumarthrogram of the right knee. Note the attenuation of the isthmus. The "body" is smaller on this side. *B*, vertical pneumarthrogram of the left knee. The "body" (slightly retouched) is again seen, separated from the patella by its "isthmus."

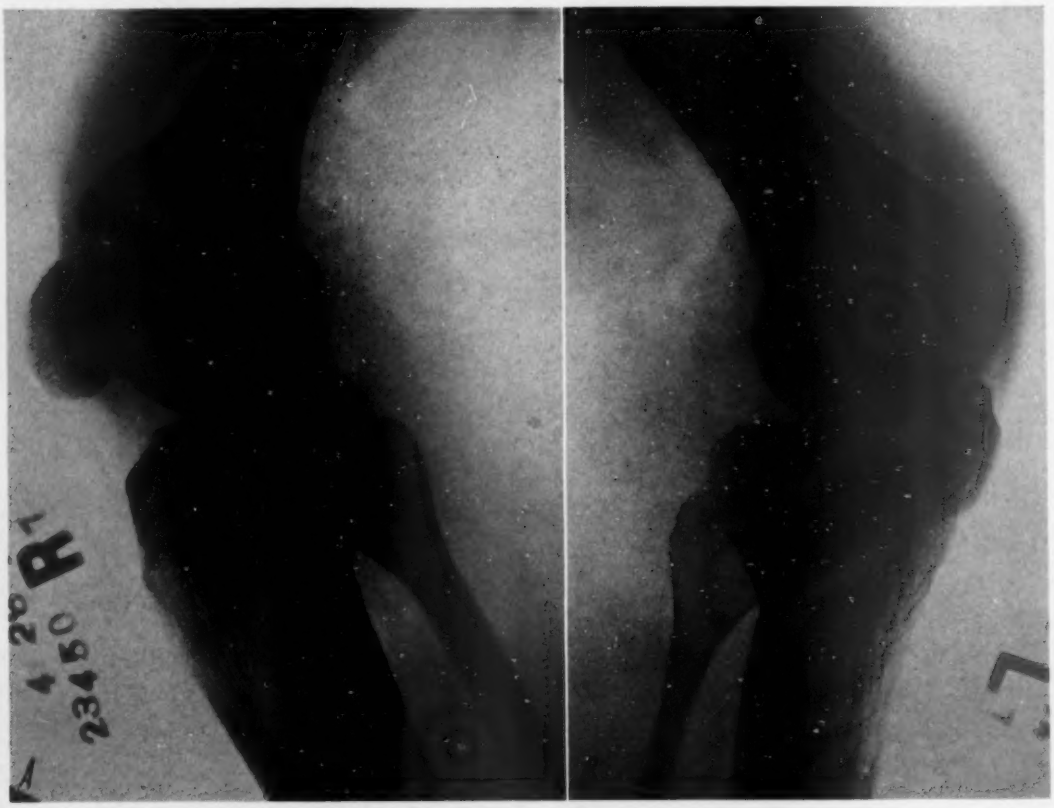

Fig. 13. Case II. Lateral views. The left patella (*B*) is at a distinctly lower level than on the right (*A*). Note that due to this difference in position the left patella reveals a trabecular system which contains an equal number of traction trabeculae and compression pillars. On the right side, the predominant system is that of many converging compression pillars.

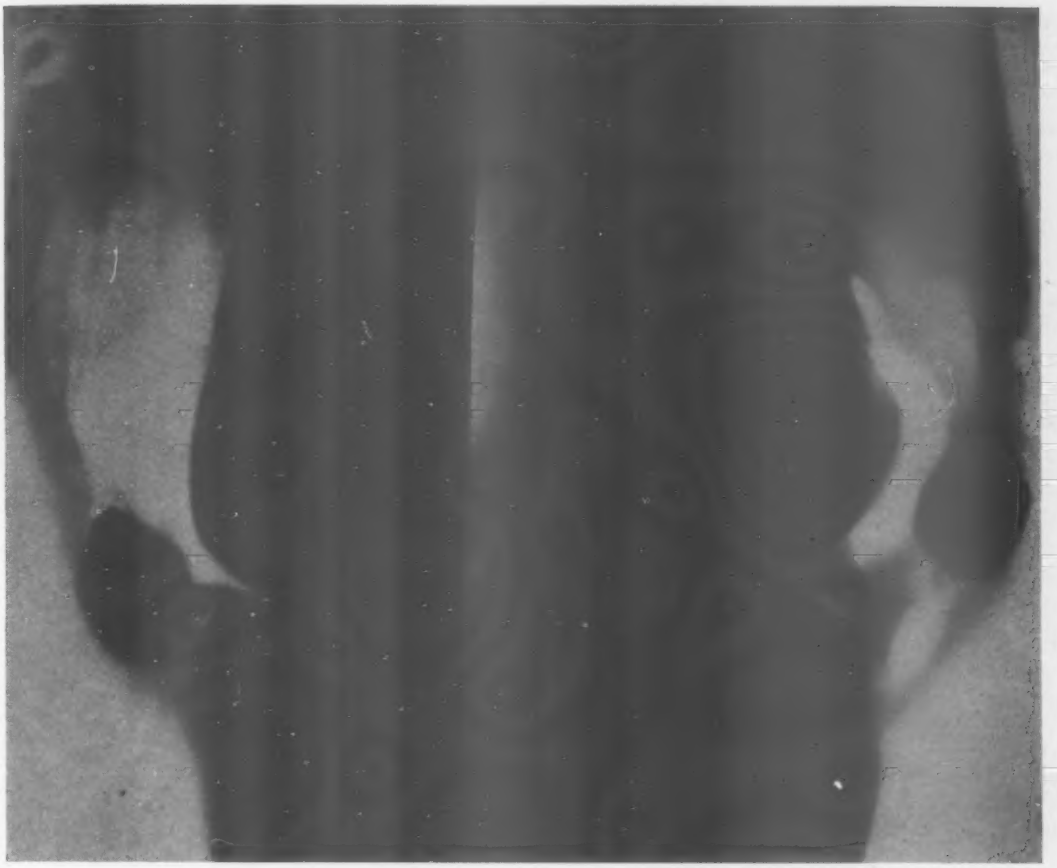

Fig. 14. Case 11. Lateral pneumarthrograms. The vertical septation is clearly defined. The infrapatellar fat pads are of normal size. The anteroposterior pneumarthrograms are not included because they were not clear enough for reproduction.

head of the left radius was found to be congenitally small and luxated.

An opportunity was also given to examine his son, aged four. Both patellae were absent. However, it is my feeling that the patellae will eventually appear in their lateral portions.

Figures 12, 13 and 14 show the later changes which might be expected to appear over a period of years. Had this individual been examined a score of years ago, I have a strong feeling that the findings would have been different. The faulty mechanics secondary to the lateral luxation tendency of the patellae have resulted in further stretching and attenuation of the capsular tissues as well as the quadriceps apparatus.

In the left knee the patella lies at a distinctly lower level than in the right. The pneumarthrograms reveal that the isthmus of tissue between the undifferentiated "body" and developed patella has become longer, thinner, and attenuated, particularly in the right knee. The septation is again visualized in both the lateral and anteroposterior views. The smaller medial and larger lateral synovial compartments are seen as well.

SPONDYLOLISTHESIS

A COMMENTARY ON ETIOLOGY, AND AN IMPROVED METHOD OF ROENTGENOGRAPHIC MENSURATION AND DETECTION OF INSTABILITY

By CAPTAIN ISADORE MESCHAN
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INTRODUCTION

SPONDYLOLISTHESIS may be defined as a forward displacement of a vertebral body secondary to a separated neural arch. The essential underlying predisposing factor is the bilateral defect in the pars interarticularis of the neural arch, which Neugebauer,[6] in 1892, called "spondylolysis or spondyloschisis interarticularis."

The diagnosis of spondylolisthesis depends primarily upon roentgenographic demonstration. However, the information obtained hitherto by the usual anteroposterior and lateral views has been deemed inadequate because:

(1) A method of diagnosis has not been clearly set out, and the roentgenologist has been confused with the terminology of prespondylolisthesis, and first, second, and third degree types.

(2) An accurate method of measuring the degree of spondylolisthesis has been lacking. It has been customary in the past to describe the displacement as a linear one. Actually, the vertebral body is displaced through a space, which usually does not lend itself to linear measurement.

(3) The degree of instability of the subluxated vertebral body has not been fully investigated. In some clinics, it has been routine in these cases to obtain an erect lateral roentgenogram (centered over the lumbosacral junction) to detect the effect of weight bearing upon the degree of instability of the subluxated vertebral body, by comparison of the erect with the recumbent roentgenogram. In some cases this is found to be inadequate, in that erect lateral roentgenograms in hyperextension and hyperflexion yield additional information regarding instability.

(4) It has not been generally appreciated that the oblique projection, as described by Hubeny[3] in 1931, shows the defect in the pars interarticularis to excellent advantage.

(5) Spondylolisthesis has, in some quarters, been too glibly referred to as a "congenital anomaly." This aspect of the disease is of special interest to the Army, where it is important to know whether or not a soldier's disability is developed in the line of duty.

We have attempted to correct these deficiencies in our study of 41 cases of spondylolisthesis, among 1,131 lumbosacral spine examinations in an overseas general hospital. A scheme has been devised for the diagnosis and accurate mensuration of the degree of spondylolisthesis, and instability of the affected vertebral body. The oblique views have been almost routine in our lumbosacral spine examinations, and an incidence of over 5 per cent with defects in the pars interarticularis has been noted. The defect may be missed if this view is omitted.

ETIOLOGY OF SPONDYLOLISTHESIS

Neugebauer's original concept was that the defect in the pars interarticularis was due to a lack of fusion of two centers of ossification, which were thought to exist to form each lateral one-half of the neural arch.

Mall[4] disproved this concept by newer methods, and his work has been further verified by others (Willis,[8] Chandler,[1] Hitchcock[2]).

Willis, however, contended that the defect in the pars interarticularis was due to a failure in ossification similar to that found in spina bifida. After studying the spines of 1,520 human skeletons, he diagrammatically showed seven positions where laminar

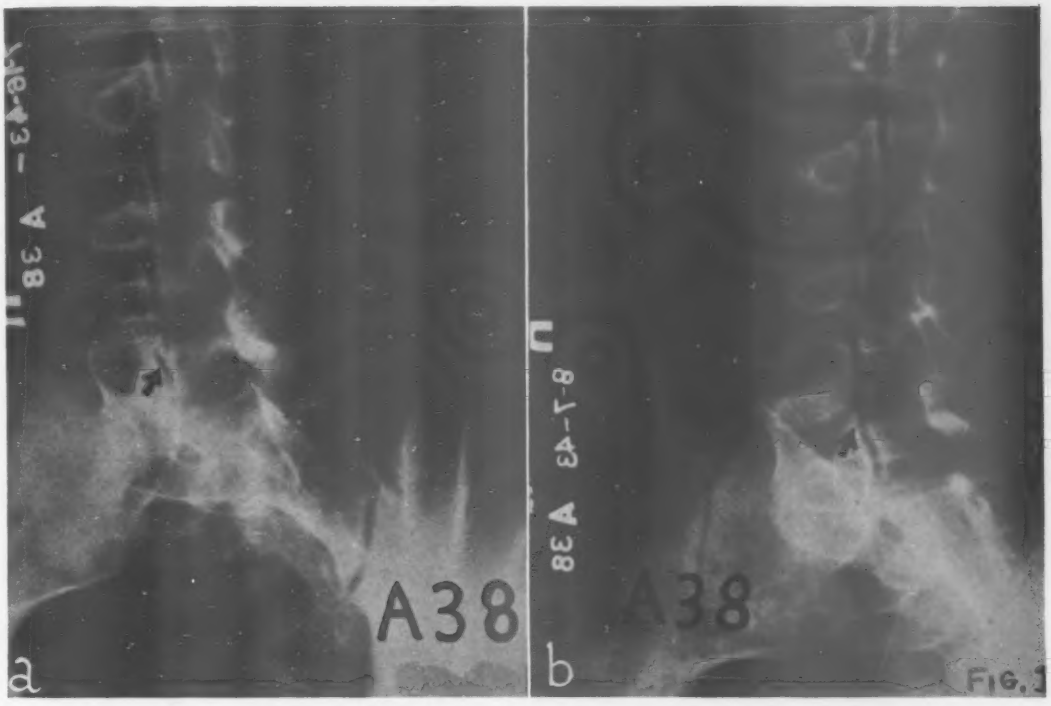

Fig. 1, *a* and *b*. Case A38. Selective action of trauma on the pars interarticularis. Value of the oblique view. Right oblique roentgenograms twenty-two days apart showing the bone resorption along the line of the defect in the pars interarticularis which occurred in this time interval. The first roentgenogram was taken one week after the patient (white male, aged twenty) fell on his back on maneuvers. The pain was very severe. Patient was treated by immobilization in a body cast for nine weeks and then discharged to duty.

separations may occur. None of these had the characteristics of fracture, such as signs of bone repair or resorption. He concluded that the actual displacement of the vertebral body was due to separation of these fibrocartilaginous areas as the result of acute or chronic trauma.

There are some who favor a completely traumatic origin for this disease. Chandler[1] and Hitchcock[2] noted that ossification of the pars interarticularis progressed by the formation of cyst-like spaces with a thin shell of bone. The pars interarticularis consists largely of cartilage and a large lake of blood vessels. Both of these authors thought this area to be particularly vulnerable to fracture. Hitchcock tested the strength of the neural arch in the lower lumbar region of newborn cadavers, and found the pars interarticularis to fracture very easily, even unilaterally. He argued that, since the defect is found at all ages, the earliest being four years, the trauma probably occurred very early in life, such as during delivery or early in the post-natal period.

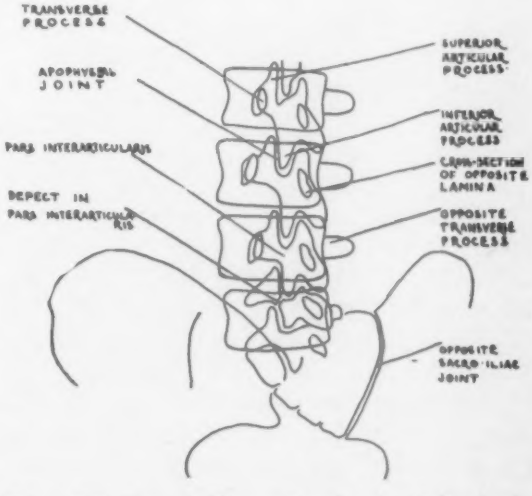

Fig. 2. Diagram of oblique view showing defect in the pars interarticularis.

The affect of trauma on the pars interarticularis was noted in one of our patients, in whom a unilateral defect in the isthmus was observed following an injury to his back. A definite increase in rarefaction of bone along the line of the defect became apparent over a period of twenty-two days (Fig. 1 and 2). There is no way of knowing whether or not the defect was there prior to the trauma, or whether it represented a true fracture. Regardless of this, however, the above findings suggest that a selective action can be exerted by trauma on the pars interarticularis.

A history of trauma associated with spondylolisthesis cannot always be elicited. Meyerding[5] reported 38 per cent (in 121 cases), and we found 43.9 per cent (in 41 cases) with a history of trauma before the onset of symptoms. The pars interarticularis is a frail segment under considerable stress and even minor traumata could fracture this isthmus, the patient forgetting the incident completely if he were not incapacitated at the time. Fractures early in life would also be unknown to the patient.

In summary, whether or not the original defect is developmental or traumatic, there

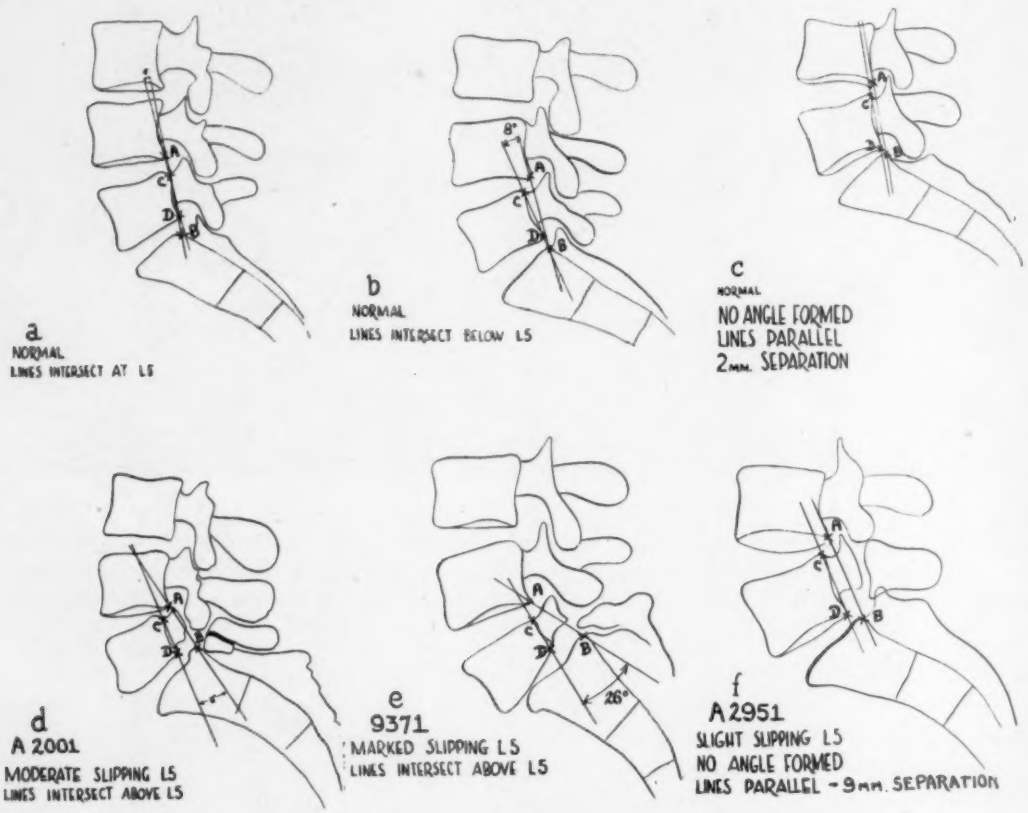

Fig. 3, *a*, *b* and *c*. Tracings of roentgenograms to show the three general types of normal lateral lumbosacral spines.

Fig. 3, *d*, *e* and *f*. Tracings to show the arrangement of the lines in cases of spondylolisthesis. The position of the apex of the angle is pathognomonic for spondylolisthesis. If the lines are parallel, in spondylolisthesis, they are separated 4 mm. or more. *d*, Case A2001. Weight bearing hyperextension. Moderate spondylolisthesis. No instability. *e*, Case 9371. Weight bearing neutral. Degree of instability between recumbent and above roentgenogram was 14°. Severe spondylolisthesis when patient stands. *f*, Case A2951. Slight spondylolisthesis, standing hyperextension. Degree of instability 6 mm. when patient's position changes from neutral standing to hyperextension.

is evidence that trauma, even of minor degrees, may widen the defect, initiate symptoms, and even start the displacement. Certainly, in the rigorous training of soldiers, with long hikes, carrying packs, lifting heavy weights, "rough-riding" in tanks, and the like, the development of spondylolisthesis is a definite possibility.

(2) Another line is drawn between the posterior upper and lower lips of the slipped vertebral body (points *C* and *D* in Fig. 3).

(3) The lines are extended, if they are not parallel, so that they meet and form a measurable angle. The position of the apex of this angle is characteristic for spondylolisthesis.

TABLE I

GENERAL ANALYSIS OF CASES

			Cases	Per cent
1. Total number of lumbosacral spine examinations			1131	100.0
2. Analysis of lumbosacral anomalies				
a. Spina bifida		293		25.9
b. Sacralization of L-5		76		6.7
c. Lumbarization of S-1		42		3.7
d. Defect pars interarticularis		57		5.1
Total number of lumbosacral anomalies			468	41.4
3. Analysis of pars interarticularis defects (spondylolysis interarticularis)				
a. Without slipped vertebra (no spondylolisthesis)		16		28.0
1. Associated anomalies in vertebra with defect	4			
2. Associated anomalies in adjacent vertebra—not in vertebra with defect	2			
3. No associated anomalies	10			
b. With slipped vertebra (spondylolisthesis)		41		72.0
1. Associated anomalies in slipped vertebra	13			
2. Associated anomalies in adjacent vertebra, but none in slipped vertebra	7			
3. No associated anomalies	21			

The disease cannot be dismissed lightly as a congenital anomaly.

MENSURATION OF SPONDYLOLISTHESIS

The displacement of the vertebral body in spondylolisthesis is seldom linear, since usually the lower portion of the vertebral body is displaced more than the upper. In the mensuration of spondylolisthesis, provision must be made for space estimation. This is done by drawing lines on the lateral roentgenogram, centered over the lumbosacral junction, as follows (Fig. 3):

(1) A line is drawn between the posterior lower lip of the vertebral body above the one involved, to the posterior upper lip of the vertebral body below (points *A* and *B* in Fig. 3).

(4) The angle between these two lines is then measured with a protractor. If the lines are parallel (very seldom in spondylolisthesis), the linear distance between the lines is measured.

This method of measurement gives an accurate concept of the degree of spondylolisthesis. If it is desired, angles up to 10 degrees can be called slight, 11 to 20 degrees moderate, and greater than 20 degrees severe. When the lines are parallel a distance of more than 3 mm. is abnormal. It is always best, however, to record accurately the displacement by reporting "a spondylolisthesis with displacement through an angle of X degrees (or rarely, a distance of X mm.)." This method also furnishes a means of measuring accurately any change

TABLE II

GENERAL ANALYSIS OF 41 CASES OF SPONDYLOLISTHESIS

1. Degrees of displacement (recumbent neutral position)	L-5	L-4	L-3
A. Angular displacement			
1. 3°–10° (slight)	30	3	1
2. 11°–20° (moderate)	4	0	0
B. Linear displacement			
2 cases—4 mm.			
1 case—3 mm. in neutral position but unstable	3	0	0
Total:	37(90.2%)	3(7.3%)	1(2.4%)

2. Stability			
A. Unstable slipped vertebral body (4 with history of trauma)		7	17.0%
1. Demonstrated by routine erect neutral film	4		
2. Requiring hyperextension for demonstration	3		
B. Stable slipped vertebral body (14 with history of trauma)		34	83.0%
1. To all methods of examination	11		
2. To neutral weight-bearing study only	23		

C. Degrees of instability

Case No.	Measurement of spondylolisthesis in: Recumbent	Neutral Erect	Neutral Hyperextension	Maximum Degree of Change
A2079	3°	3°	6°	3
A3761	17	17	20	3
A2951	3 mm.	3 mm.	9 mm.	6 mm.
9371	12°	26°	Not done	14
76	9	12	Not done	3
9538	7	15	Not done	8
1274	9	12	Not done	3

3. Disposition of cases			
A. Transferred to United States		24 cases	58.5%
B. Limited duty in this area		2	4.8%
C. Transferred to another hospital in this area		1	2.4%
D. Discharged to full duty		14	34.3%
4. Total number of cases of spondylolisthesis with history of trauma		18	43.9%
A. Unstable	4 cases		
B. Stable	14		

which occurs in weight bearing, flexion, and extension by comparison of the measured angle on each of these roentgenograms. A measurement of the degree of mobility of the vertebrae in these relative postures is to be preferred to superposition of tracings apart from its descriptive value, because the vertebrae are in different relative positions when flexed, and when extended, and cannot be superimposed.

The accuracy of this method of mensuration depends entirely upon the quality of roentgenograms obtained. The posterior margins of the vertebrae and sacrum must be clearly identified for accurate estimation of small degrees of change. We have found the method probably to be accurate to within an angle of 2 degrees.

CASES STUDIED AND TABULAR RESULTS

(*See Tables I and IV*)

There were a total of 1,131 lumbosacral spine examinations in twenty-two months in this overseas general hospital (April,

1942 to February, 1944). There were 57 cases with defects of the pars interarticularis; 41 with spondylolisthesis and 16 without.

All of the cases of spondylolysis interarticularis were studied with routine anteroposterior, oblique and lateral recumbent and erect neutral projections.

In addition, the last 18 cases of spondylolisthesis and 15 normal patients were studied with additional erect lateral roentgenograms in hyperextension and hyperflexion, as shown in Figure 4.

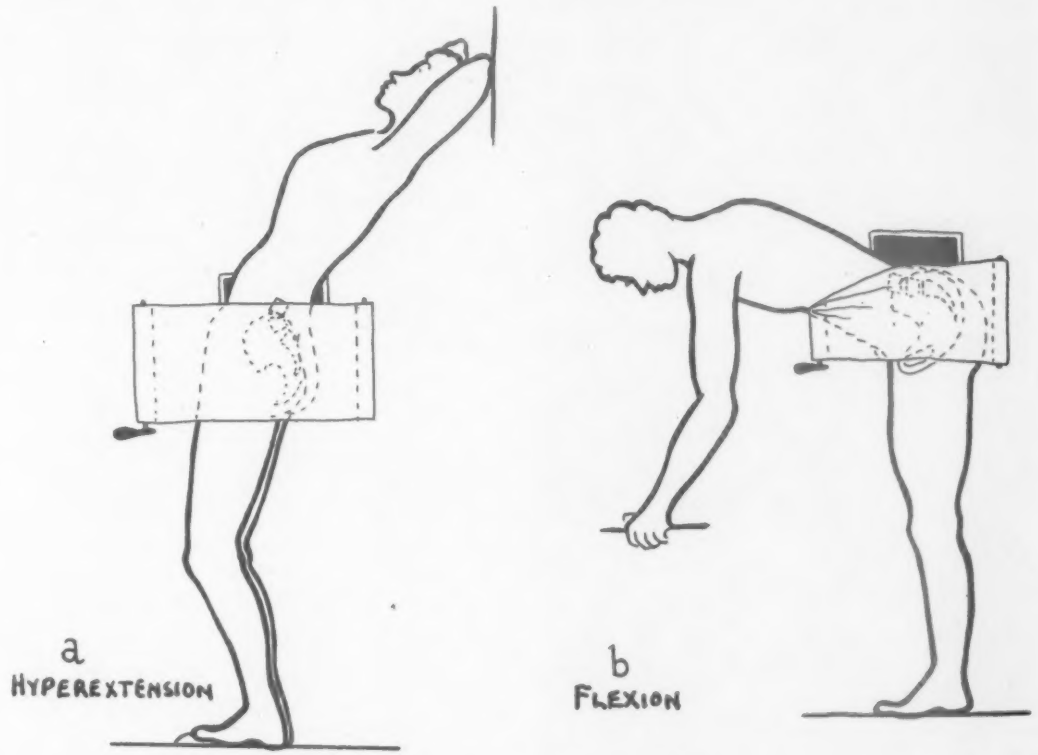

FIG. 4, *a* and *b*. Weight bearing flexion and hyperextension posturing diagram. Diagrams show method of posturing patient for standing lateral views of the lumbosacral spine in hyperextension and hyperflexion. (The degree of flexion is varied with the patient's tolerance.) The supports are merely used to steady the patient and not to diminish the weight-bearing function of the spine. The immobilization band is placed at pelvis level.

Average Technique: 30 ma., 78 kv. (peak), 36 inch target-to-film distance, 9 second exposure (small 2.0 mm. focal spot, par speed screens, long cylindrical cone 7.5 cm. in diameter, Potter-Bucky diaphragm).

Table II summarizes the pertinent findings among the cases of spondylolisthesis. The mensuration of the degree of spondylolisthesis can be arbitrarily divided into three categories:

3° to 10° displacement—slight
11° to 20° displacement—moderate
Greater than 20° displacement—severe

The fifth lumbar vertebral body was involved in 37 cases with the degree of displacement falling into the following groups:

Angular displacement, 34 (slight, 30; moderate, 4)
Linear displacement, 3

The fourth lumbar vertebral body was involved in slight displacement in 3 cases.

The third lumbar vertebral body was displaced in 1 case through an angle of 8 degrees.

A total of 7 patients had demonstrable instability of the displaced vertebral body —4 of which could be demonstrated by a comparison of the routine weight-bearing

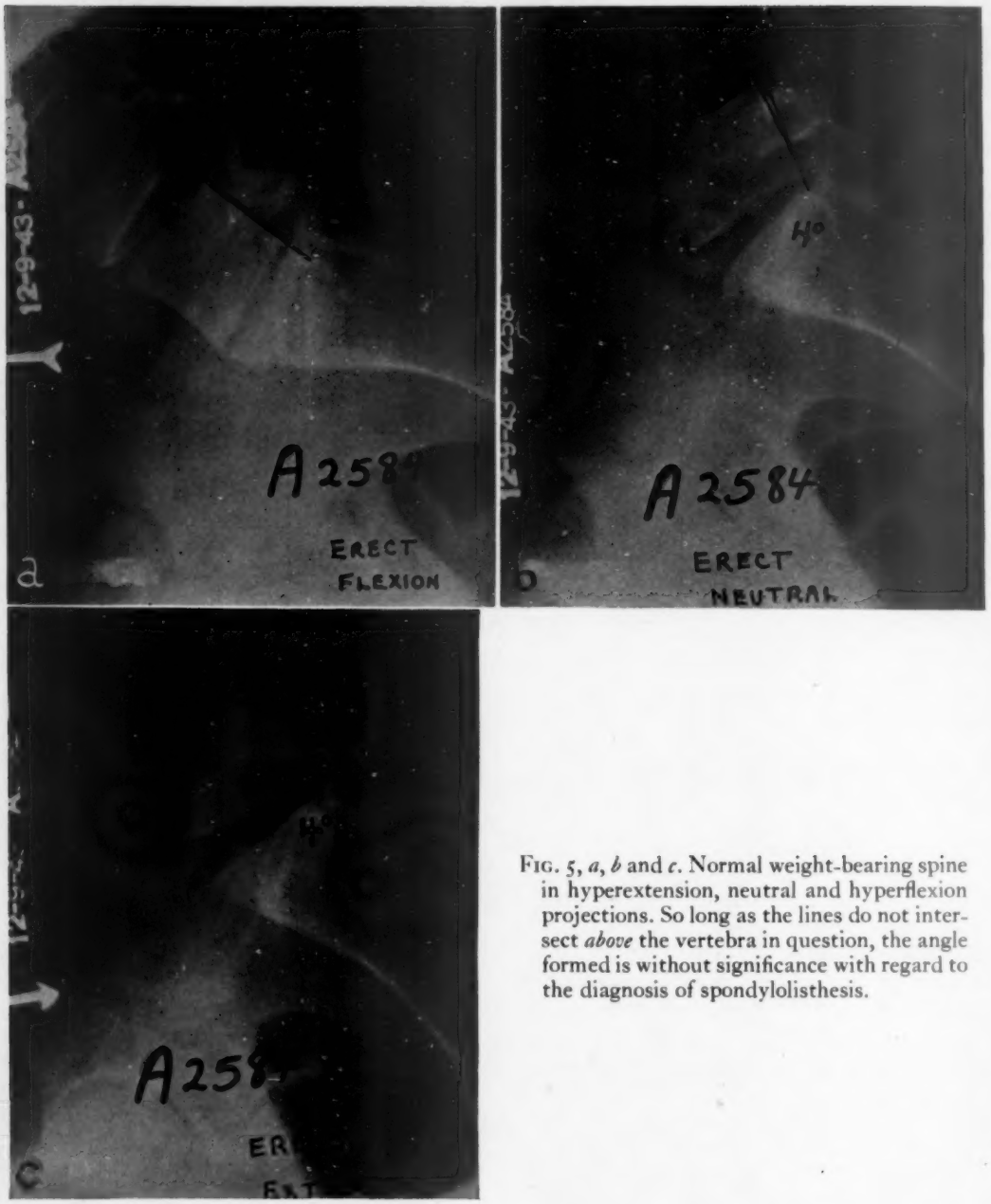

Fig. 5, *a*, *b* and *c*. Normal weight-bearing spine in hyperextension, neutral and hyperflexion projections. So long as the lines do not intersect *above* the vertebra in question, the angle formed is without significance with regard to the diagnosis of spondylolisthesis.

neutral lateral roentgenogram with the recumbent neutral view. The remaining 3 cases required the additional special views in flexion and extension. The maximum degree of instability in these 7 cases is shown in Table II. This varied from 3 to 14 degrees of angular displacement, and 6 mm. of linear displacement in 1 case.

A history of associated trauma prior to the onset of symptoms was obtained in 4 out of the 7 unstable cases (57 per cent), and 14 out of the 34 stable ones (41 per cent), or 43.9 per cent of the total number of cases of spondylolisthesis.

Mensuration: Normal vs. Spondylolisthesis

(*On Lateral Views of Lumbosacral Spine*)

A. *General Remarks.* The method of mensuration outlined previously on any

lateral lumbosacral roentgenogram gives a pathognomonic configuration of the lines in spondylolisthesis (Fig. 3, *d, e, f*).

In the normal, the lines always either intersect below or at the level of the fifth lumbar vertebra; or if they are parallel (Fig. 3, *a, b, d* and Fig. 5) to one another, they are never more than 3 mm. apart.

In spondylolisthesis, the two lines practically always intersect above the slipped vertebral body. Very rarely (3 cases out of the 41), they are parallel (Fig. 3*f*), but at a distance greater than 3 mm.

These differences hold true no matter what position the patient is in when the lateral roentgenograms are taken.

B. *Weight Bearing Neutral vs. Recumbent Neutral.* In the normal, the angle or relationship of the lines does not change significantly when the patient changes from the recumbent to a weight-bearing neutral position.

In spondylolisthesis (Fig. 6 and 7), the slipped vertebral body may or may not become displaced more with the added strain of weight bearing. Increased displacement with weight bearing is interpreted as indicating instability of the lumbar spine. Instability was thus demonstrated in 4 cases of spondylolisthesis (9.8 per cent). The angles of displacement increased from 3 to 14 degrees in these cases.

The lower surface of the unstable vertebral body usually moves more than the upper, in "rocking chair" fashion, with the upper posterior lip (point *C*) acting more or less as a pivot.

C. *Standing Spine in Hyperflexion.* In the normal flexed lumbar spine, the two lines usually approach one another and may even become superimposed (Fig. 5). This would indicate that the upper surface of the fifth lumbar vertebral body moves less than the lower, the opposite of that noted previously for the unstable vertebral body in spondylolisthesis.

In spondylolisthesis, when the spine as a whole is flexed, the arms of the angle usually remain in the same relative position to one another, as in the neutral position. A change greater than 1 or 2 degrees is rarely observed, and it is difficult to be certain that this is outside the margin of error. This is evidence that the slipped vertebral body and adjacent vertebrae remain relatively fixed with respect to one another when the spine is flexed.

The standing film in hyperflexion will also usually demonstrate the defects of the pars interarticularis to better advantage than the routine neutral projection (Fig. 8).

D. *Standing Spine in Hyperextension.* Normally, when the spine is hyperextended, the lines usually remain in the same relative position to one another as in the neutral position.

With spondylolisthesis, hyperextension of the lumbar spine will occasionally demonstrate instability when the weight-bearing neutral roentgenogram fails to do so. Thus, in 2 cases, the angle of displacement increased by 3 degrees with this method, and in 1 case, by 6 mm. of linear movement, when the neutral weight-bearing roentgenogram failed to demonstrate instability (Fig. 9).

VALUE OF ROUTINE ROENTGENOGRAMS IN THE STUDY OF SPONDYLOLISTHESIS

A. *Oblique Views.* The right and left anteroposterior oblique views of the lumbar spine are taken by placing the patient in the recumbent position, and turning his right and left side up respectively, so that his back forms an angle of 35 to 45 degrees with the table. The degree of obliquity must be varied in some patients depending upon the degree of obliquity of the lumbar facets.

In interpreting these roentgenograms, it must be recalled that the facets nearest to the film are parallel to it, or horizontal, and hence are the facets shown to best advantage (Fig. 1, 2 and 8). Likewise, the apophyseal joints nearest the film are the ones clearly visualized; but because the plane of the sacroiliac joints is perpendicular to the plane of the apophyseal joints, it is the opposite sacroiliac joint which is clearly shown.

The importance of these views for the visualization of defects in the pars inter-

articularis has not been fully appreciated. This is especially true when the defect is unilateral, in which case the routine lateral view usually does not show the defect. In cases with bilateral defects in the pars interarticularis, these can usually be demonstrated in the straight lateral projection, as well as the oblique projections (Fig. 6, 7, 8 and 9). Occasionally, however, a bilateral defect could readily be overlooked if special lateral views in hyperflexion were not obtained, as outlined previously, and if oblique views were also omitted (Fig. 8).

The defect in the pars interarticularis is seen in the oblique projection as a discontinuity with jagged saw-toothed margins. The line of dissolution may measure 1 or more millimeters. Usually, the upper tip of the superior articular process of the vertebra below points directly toward the de-

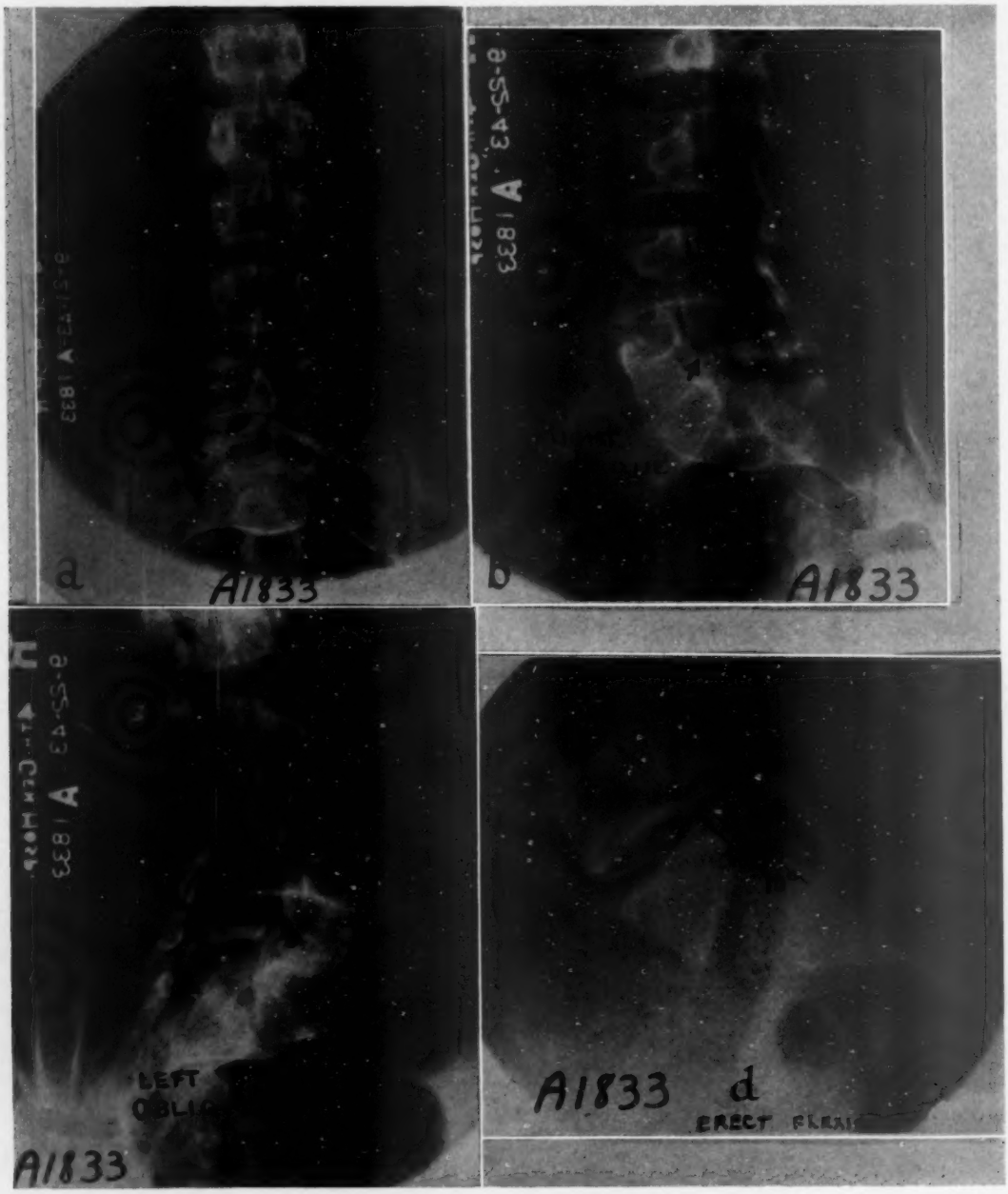

Fig. 6. See opposite page for legend.

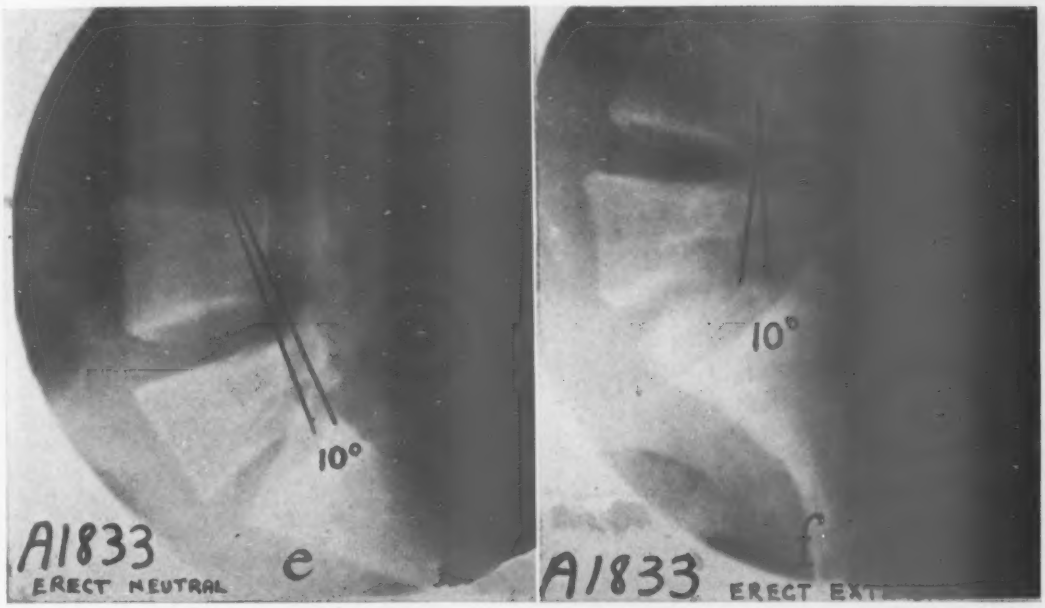

FIG. 6, *a*, *b*, *c*, *d*, *e* and *f*. Case A1833. Spondylolisthesis with no instability. Angle of displacement is 10° in all lateral views. The spondylolysis interarticularis is clearly shown. There is an associated spina bifida of the affected vertebral body.

Case Résumé. This soldier, aged twenty, who was admitted for malaria, fell off a tram one month previously. He complained of occasional back pain intermittently. There was no back disability. *Disposition:* duty.

fect. Occasionally, with wider separation of the fragments, the superior facet of the vertebra below appears to project directly into the defect, partially obscuring it.

Although the outline of the fragments appears jagged, there is a softness of definition of the margins. It is not certain that fracture can be considered a possibility; if so, however, the appearance is usually that of a remote, ununited fracture without any evidence of bone repair or absorption.

Willis found an incidence of 5.2 per cent of defects of the pars interarticularis in 1,520 human skeletons selected at random, varying in age from twenty-five to ninety years. The incidence was equal in the various age groups.

Among 1,131 roentgenographic lumbosacral spine examinations (Table 1) in twenty-two months, we found 5.1 per cent with this defect (57 cases). This number includes the 41 cases of spondylolisthesis. All of these examinations were carried out on patients complaining of low back pain.

Our series is not comparable with that of Willis, since the latter included adult skeletons selected at random, whereas our patients were soldiers carefully selected for Army service who complained of back pain.

Defects of the pars interarticularis (usually found in the fifth lumbar vertebra) comprised approximately one-eighth of all anomalies of the lumbosacral region, including sacral spina bifida. They were one-fifth as frequent as all types of spina bifida. For the sake of convenience, we have considered defects of the pars interarticularis among the lumbosacral anomalies, but we are by no means certain that this defect is truly an anomaly. This matter has been discussed previously.

Seventy-two per cent of cases with defects of the pars interarticularis also had a spondylolisthesis, and 28 per cent did not.

B. *Anteroposterior Views.* Willis[7] maintained that, in cadavers with known defects in the pars interarticularis, he frequently found it impossible to detect posi-

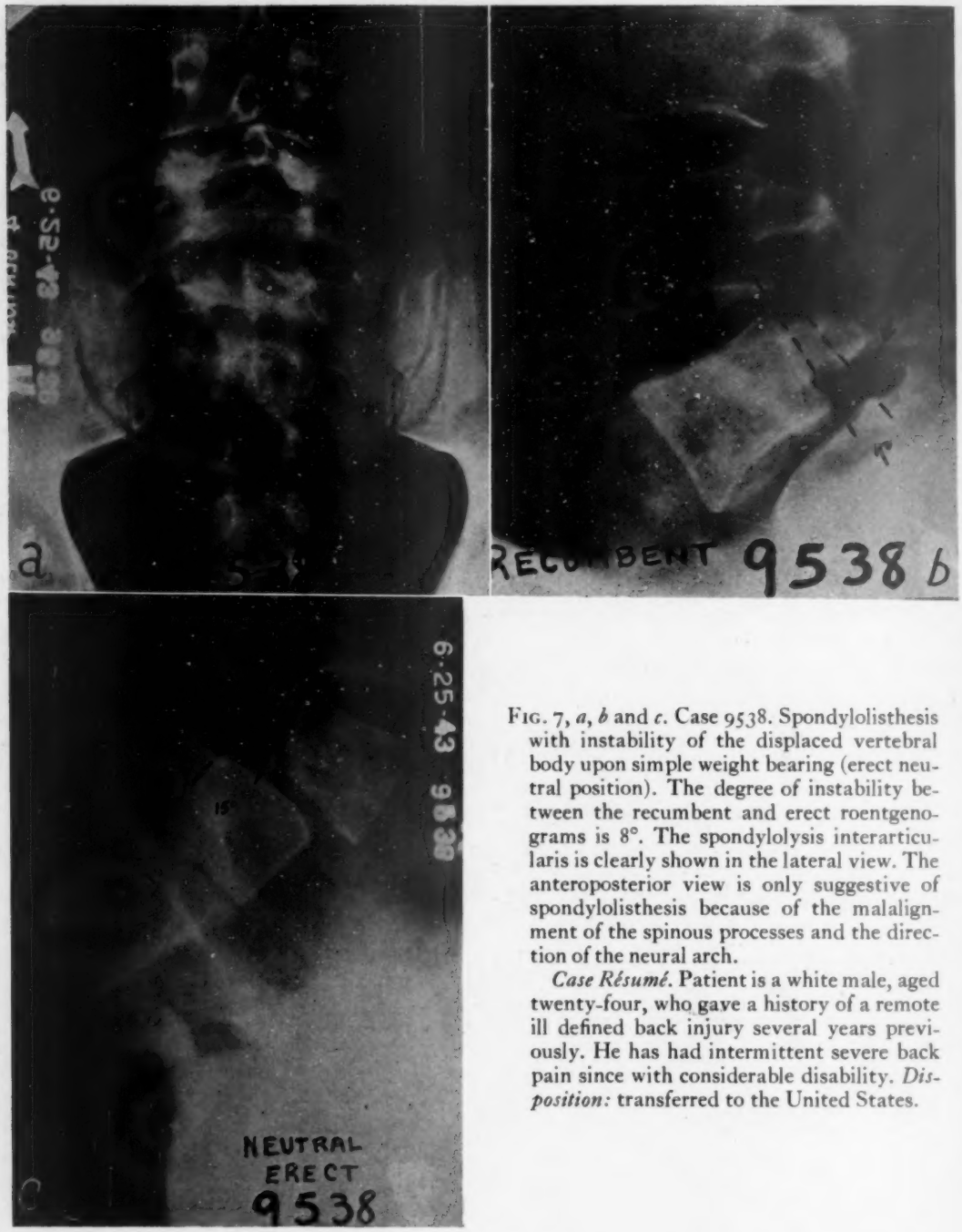

Fig. 7, *a*, *b* and *c*. Case 9538. Spondylolisthesis with instability of the displaced vertebral body upon simple weight bearing (erect neutral position). The degree of instability between the recumbent and erect roentgenograms is 8°. The spondylolysis interarticularis is clearly shown in the lateral view. The anteroposterior view is only suggestive of spondylolisthesis because of the malalignment of the spinous processes and the direction of the neural arch.

Case Résumé. Patient is a white male, aged twenty-four, who gave a history of a remote ill defined back injury several years previously. He has had intermittent severe back pain since with considerable disability. *Disposition:* transferred to the United States.

tive roentgenographic evidence of the condition. He recommended the anteroposterior stereoscopic views as the most satisfactory—but even with this method the diagnosis was apparently made by inference from "a delimitation laterally of the laminae" which he came to regard as diagnostic of the condition. In our studies, we have found the anteroposterior projection helpful, but not diagnostic. Apart from the delimitation of the laminae laterally which Willis described for detection of defects in

Fig. 8, *a*, *b*, *c* and *d*. Case A3511. Bilateral spondylolysis interarticularis without spondylolisthesis. Only one oblique view with an unusual small defect in the pars interarticularis is shown. The defect on the other side is typical and not shown. The roentgenogram in erect hyperflexion shows the accentuation of the defect in hyperflexion. The diagnosis could not be made from the anteroposterior projection.

Case Résumé. White male, aged twenty-three, with low lumbar backache, associated with nonspecific urethritis. There was no history of trauma. *Disposition:* full duty.

the pars interarticularis, there are other findings which are contributory to the diagnosis of the spondylolisthesis:

1. The spinous process may be out of line with respect to the spinous process above it (Fig. 7).

2. In advanced spondylolisthesis, the body of the slipped vertebra is projected

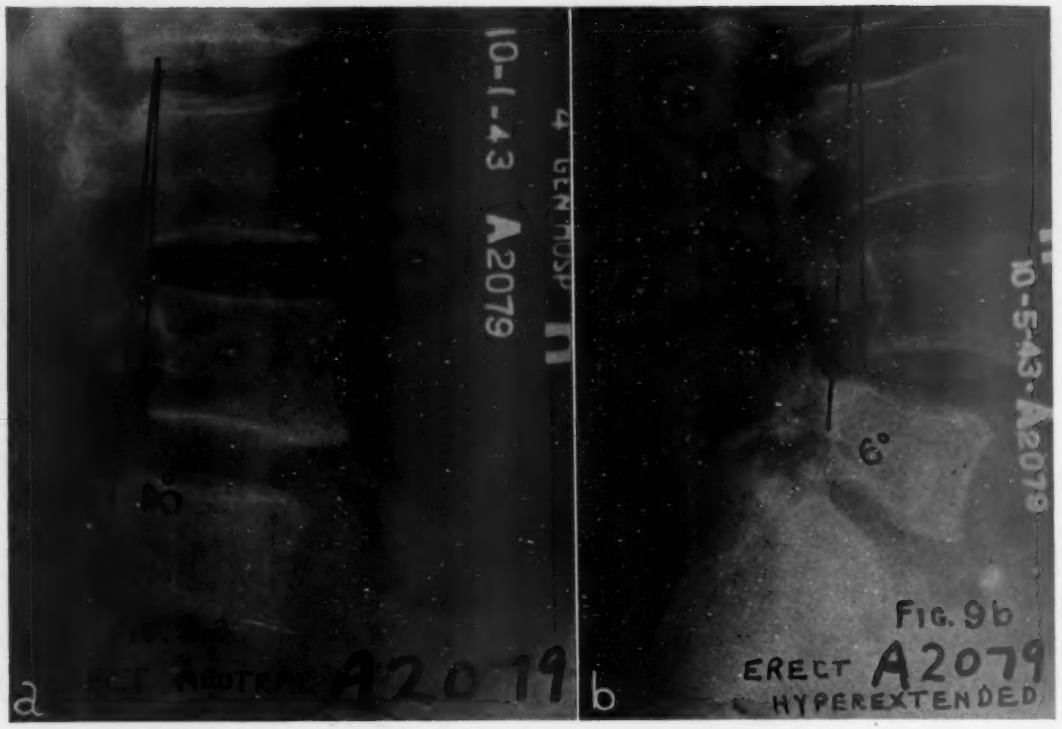

Fig. 9, *a* and *b*. Case A2079. Spondylolisthesis with instability demonstrated by hyperextension of the spine, but not by simple weight bearing in the neutral position. The instability between the erect neutral and hyperextended positions is 3°. The slipped vertebral body is the fourth lumbar. The spondylolysis interarticularis is clearly shown.

Case Résumé. Patient is a white male, aged thirty-two, who was twice thrown from a horse—first in 1942, next seven months ago. Previous roentgenographic studies in 1942 were reputedly negative elsewhere. His chief complaint was pain radiating down his left thigh on bending. *Disposition:* transferred to the United States.

as superimposed upon the upper sacrum, and its spinous process points upward (the so-called "bow and arrow" appearance).

This condition is also frequently associated with lumbosacral anomalies (49 per cent, Table 1). However, lumbosacral anomalies were found in 41.4 per cent of all lumbosacral examinations. With such a high incidence of anomalies, and such a relatively low incidence of spondylolisthesis (3.6 per cent), this factor is hardly of much value in diagnosis.

None of these findings in the anteroposterior view are diagnostic; not infrequently they are misleading. The lateral and oblique views must always be taken to prove or disprove what is suspected from the anteroposterior study, not only with regard to spondylolisthesis but also with regard to defects in the pars interarticularis.

C. *Lateral Views.* In the lateral views, the defect in the pars interarticularis is seen as a discontinuity in the neural arch of the involved vertebra along the posterior margin of the spinal canal (Fig. 6, 7, 8 and 9). In contrast to the appearance in the oblique projections where the margins of the defect appear very irregular and saw-toothed, the defect as seen in the lateral projection usually appears more rounded and smooth. The defect is seen most clearly in the lateral projection when the spine is flexed (Fig. 8) and could be overlooked if this additional view were not obtained.

In lumbar spine anatomic specimens of "the separate neural arch," Willis found a marked bevelling of the sacrum and associated hypertrophic changes. The roent-

genographic counterpart of these changes is best seen in the lateral views. The upper anterior margin of the sacrum is rounded, and the entire upper surface presents a horizontal S configuration. The interspace below the slipped vertebra is usually narrowed. There may be associated bony lipping and sclerotic changes of the adjoining bony surfaces of this interspace. These changes are attributed to the rocking movement of the loose vertebral body on the upper surface of the sacrum (Fig. 6 and 7).

SUMMARY

1. Spondylolisthesis can be recognized by means of the position of the apex of the angle formed when lines are drawn as described. The apex always falls above the vertebral body in question. If the lines are parallel the distance between them is 4 millimeters or more.

2. The degree of spondylolisthesis can be accurately measured, by determining the angle between these lines, if an angle is formed. In a few cases (3 out of 41), the lines may be parallel, and the linear distance between them is then measured.

3. This method of mensuration is also used in the determination of the degree of instability of a slipped vertebral body by comparing lateral roentgenograms of the lumbosacral spine taken with the patient lying down, and standing in the neutral, hyperflexion, and hyperextension positions.

4. The cases of spondylolisthesis observed at this overseas Army general hospital in twenty months are reviewed with regard to these special methods of examination. Among 1,131 lumbosacral spine studies, 41 cases of spondylolisthesis were noted in 57 patients with defects of the pars interarticularis.

5. The displaced vertebral body in spondylolisthesis may or may not be stable. Thus, 7 of the 41 cases of spondylolisthesis were found to be unstable; 4 of these could be demonstrated by comparison of the recumbent with the weight-bearing (standing) neutral roentgenogram: 3 cases revealed instability only after a roentgenogram in hyperextension was compared with the other views.

6. The value of the oblique roentgenogram of the lumbosacral spine for demonstration of defects of the pars interarticularis is emphasized, There is an incidence of over 5 per cent of this defect.

7. Objection is made to referring to spondylolisthesis universally as a congenital anomaly. The evidence at hand suggests that trauma may widen the defect, initiate the symptoms, and start the displacement of the vertebral body. An unequivocal opinion in either direction cannot be stated.

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PLEURITIC INVOLVEMENT ASSOCIATED WITH PRIMARY ATYPICAL PNEUMONIA

A ROENTGENOGRAPHIC AND CLINICAL STUDY

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DURING the course of routine roentgenograms of the chest in the examination of a large number of soldiers, pulmonary findings characteristic of atypical pneumonia were observed in about 0.3 per cent of the examinees. In this group, pleuritic involvement, particularly of the lower ends of the interlobar fissures, was found in a comparatively large percentage. In view of the interesting, consistently similar roentgen findings and the infrequency of reports of pleural manifestations in primary atypical pneumonia, a detailed report of these cases is presented.

A comprehensive review of the extensive literature concerning atypical pneumonia and related syndromes revealed relatively few reports of associated pleural involvement.[3,10,31,33,36] Of these, a considerably smaller percentage was described as involving the interlobar fissure. Reimann[29] reported 11 cases of clinically severe atypical pneumonia and recorded pleuritic processes in four. Two of these showed a thickening of the interlobar pleura, and in 1 case a small collection of sterile fluid was found in the costophrenic sinus. Dochez[5] noted that it was not unusual for the pleura to be affected during the course of this disease. A tendency toward involvement of the interlobar pleura in clinically severe cases was also reported by Smiley, *et al.*[34] Findings similar to our own were described by Crysler[4] in 178 cases. He recorded pleurisy with effusion as occurring only rarely, but found evidence of co-existing interlobar or parietovisceral pleural thickening in 22 of the cases in which the parenchymal infiltrations were situated adjacent the pleura. In the large majority of other reports either no pleural involvement was mentioned or rare occurrences of clouding of the costophrenic sinus were noted (Table 1).

The anatomical course of the interlobar fissures in the frontal and lateral view roentgenograms is shown in composite diagrams (Fig. 1, *A* and *B*) derived from Gray,[12] Levitin and Brunn[17] and from our own roentgenograms made during deep inspiration. The location, shape and appearance of the fissures in the oblique views are well demonstrated in the cadaver studies and illustrations of Peirce and Stocking[26] (Fig. 2). The lower ends of the long fissures on either side are of particular interest for this report. In the frontal view, the right long fissure extends obliquely downward and inward, reaching the diaphragm in the cardiophrenic angle at about the level of the seventh costal cartilage. On the left side the long fissure extends downward and inward in a similar manner, but crosses the dense shadow of the lower left lateral margin of the heart just before reaching the diaphragm opacity also at about the same level. In the lateral view, the appearance of both long fissures is essentially the same. The lower halves of these fissures are seen only through the opacity of the cardiac shadow and, at their inferior ends, the fissures dip just below the densities of the anterior edges of the diaphragms. A considerable difference is noted between the lower portions of the right and

TABLE I

REVIEW OF LITERATURE: ROENTGENOGRAPHIC PLEURAL MANIFESTATIONS WITH ATYPICAL PNEUMONIA

Authors	Total Cases Atypical Pneumonia	Cases with Pleurisy	Location of Pleurisy		Pleural Involvement
			Costophrenic Sinus	Interlobar Fissure	
					Per cent
Reimann[29]	11	4	2	2	36.4
Miller and Hayes[22]	35	1	—	—	2.8
Murray[24]	81	1	—	—	1.2
Goodrich and Bradford[10]	52	2	—	—	3.8
Green and Eldridge[11]	110	1	—	—	0.9
Haemig and Heyden[15]	59	2	—	2	3.4
Rhoads[31]	31	2	—	—	6.5
Hufford and Applebaum[14]	27	1	1	—	3.7
Campbell, *et al.*[3]	200	12	—	—	6.0
Needles and Gilbert[25]	125	1	—	—	0.8
Crysler[4]	178	22	—	—	12.3
Warren, Higley and Harrison[36]	480	22	22	—	4.6
Showacre, *et al.*[33]	196	?	—	—	0–3.0 varying with season
McCarthy[22]	590	Rare	—	—	—
Kneeland and Smetana[15]	52	Occasional	—	—	—
Drew, Samuel and Ball[6]	50	Occasional	—	—	—
Others[1,7,9,16,19,20,21,28,30,32,37]	782	0	—	—	0

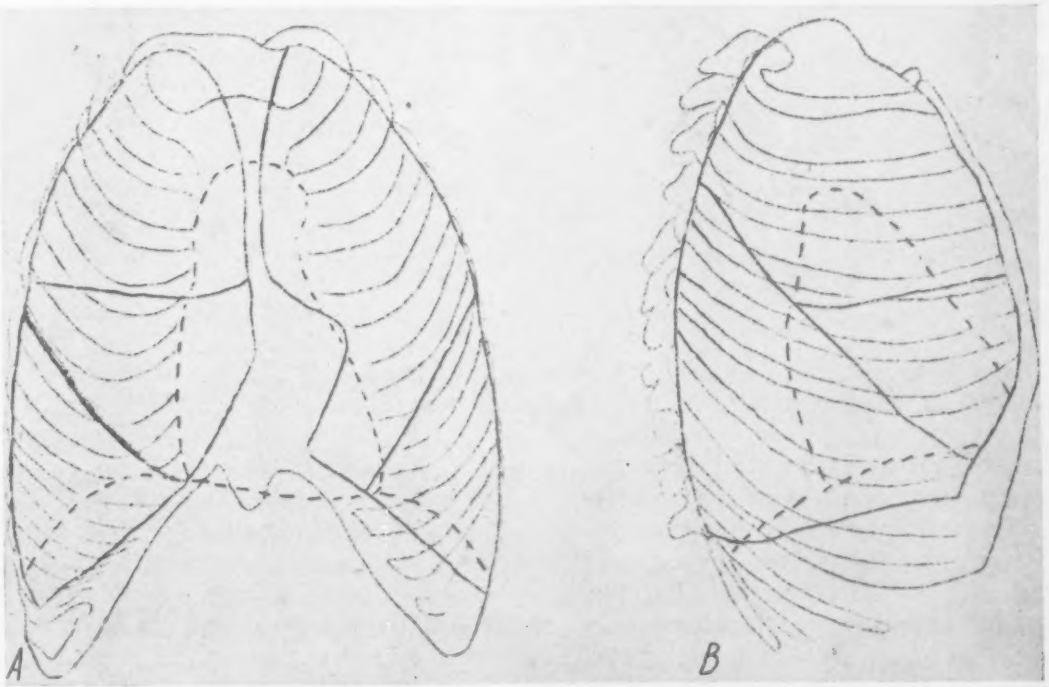


FIG. 1. *A*, appearance of fissures in frontal view. *B*, appearance of fissures in lateral view. The long fissures in the right and left lungs occupy the same position.

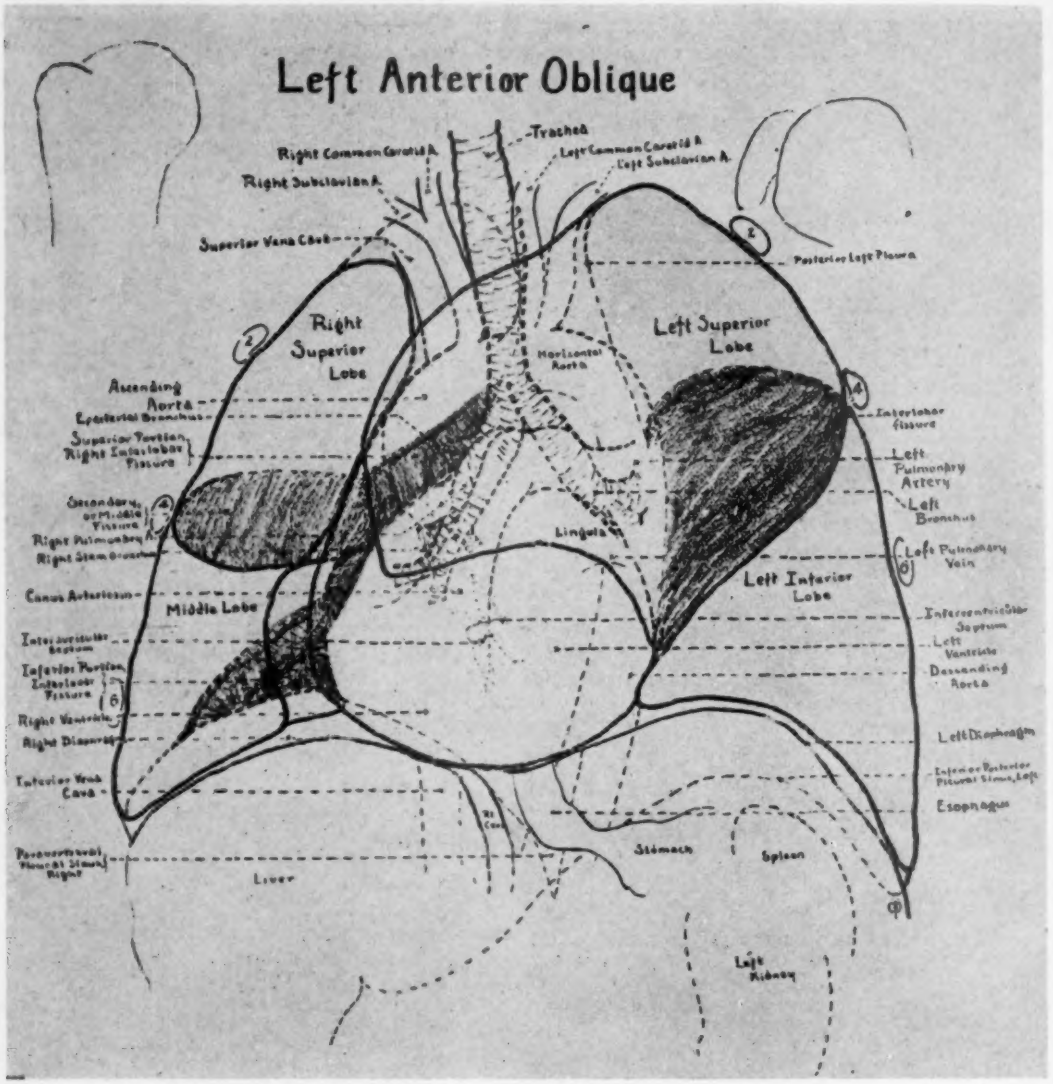
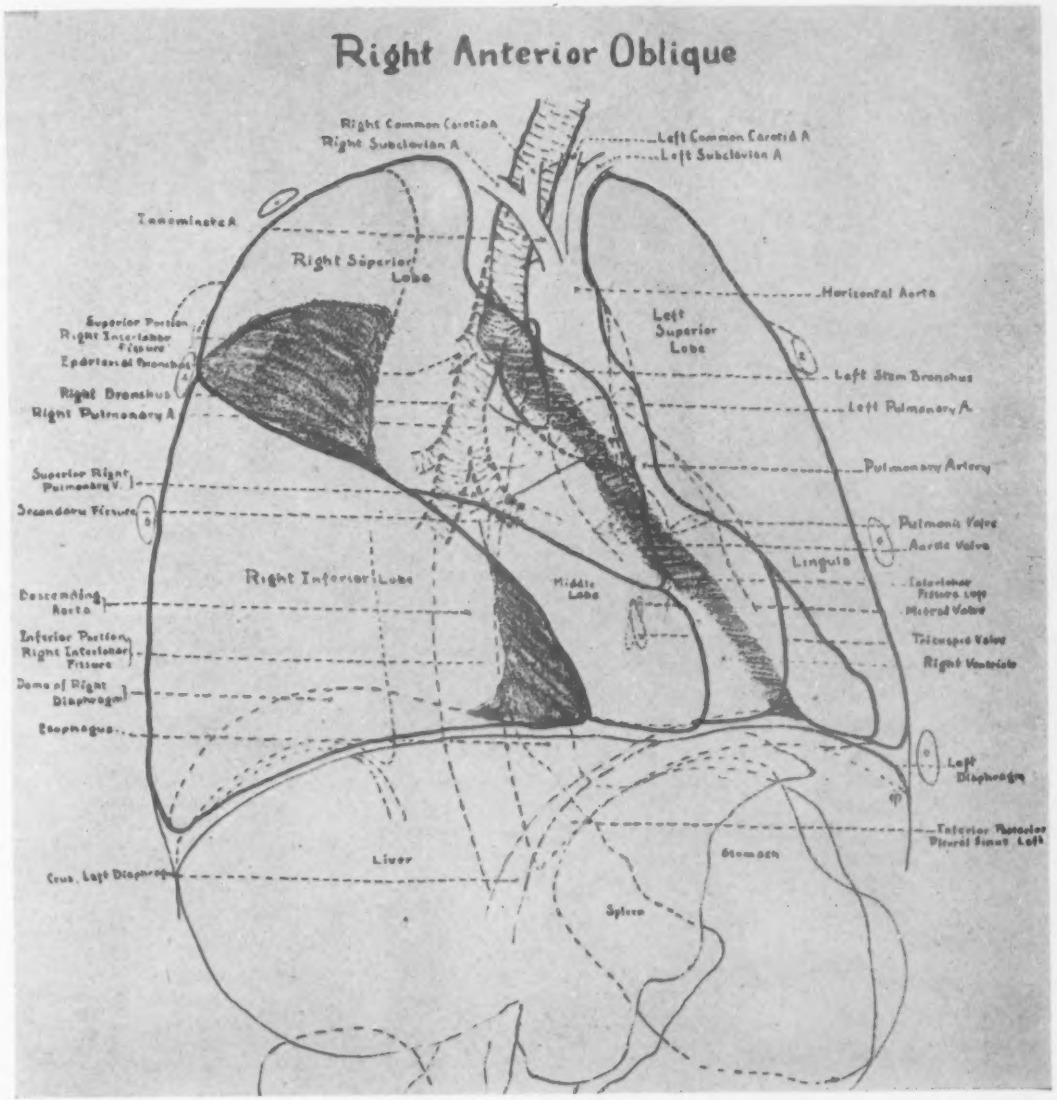


FIG. 2. Appearance of fissures in the oblique views. The

left main fissures in the oblique view. In the left anterior oblique view the inferior end of the right long fissure is triangular in shape and rests on the mesial surface of the diaphragm adjacent the lower right anterior border of the heart. However, in the right anterior oblique roentgenogram, the inferior half of the left long fissure is merely band-like in appearance and, for most of its length, is obscured by the overlying cardiac density. Only the small portion of its lower end which rests on the diaphragm extends beyond and lies adjacent to the lower left anterior border of the heart.

Our series of primary atypical pneumonia consisted of 144 cases. Of these, 21 (14.5 per cent) showed definite evidence of pleural involvement (Table II). In 11 cases (7.6 per cent) there was a pleuritic process essentially limited to the lower end of the longitudinal fissure with little or no roentgenographic evidence of adjacent pulmonary parenchymal involvement. Seven cases (4.8 per cent) showed an atypical pneu-



area and position they occupy are shaded a dark gray.

monic type of infiltration associated with thickening of the lower end of the long fissure. The infiltrations were either in lobes adjacent to the involved fissure or in the opposite lung. In 3 cases (2.1 per cent) the costophrenic sinus was the site of the pleuritis and the long fissures appeared normal. One of these patients showed a considerable effusion in the general pleural space.

The clinical syndrome of 20 cases with pleuritic involvement was essentially identical with that of the remaining 123 cases of primary atypical pneumonia without evidence of pleuritis. The course of the 1 patient with extensive pleural effusion was somewhat more protracted. The cases appeared sufficiently similar to permit a discussion of the clinical manifestations of the group as a whole. The entire series of 144 cases was found during a routine processing chest examination employing a photoroentgen apparatus. The pulmonary abnormalities were clearly visualized on the stereo-

scopic pair of 4 by 5 inch films. Regular 14 by 17 inch films were used in the confirmatory studies.

The majority of the examinees, although found to have respiratory tract symptoms on questioning, were not sufficiently incapacitated to seek medical aid. A small number of these patients who attended sick call for "colds" had normal temperatures and no abnormal physical findings in their chests.

TABLE II

PLEURAL INVOLVEMENT IN 21 CASES OF PRIMARY ATYPICAL PNEUMONIA

	Cases
I. Lower ends of long fissures involved with no or minimal co-existing process in pulmonary parenchyma	11
Right long fissure	7
Left long fissure	4
II. Lower ends of long fissures involved with a significant co-existing process in pulmonary parenchyma	7
Right long fissure	3
Left long fissure	4
III. Costophrenic sinus pleural involvement with a significant co-existing process in adjacent pulmonary parenchyma	3
Right sinus	1
Left sinus	2*

* One of these patients had an extensive effusion involving the general pleural cavity.

The patients were eighteen to twenty-six years of age. The duration of symptoms prior to the discovery of the pulmonary process varied from one to two weeks in the majority of cases. In a few instances, they were of four days' duration, and 1 patient had been coughing for two months. Cough was the most common complaint. It was almost invariably worse at night and often produced a moderate amount of mucoid or mucopurulent sputum. Malaise, chilliness (but not shaking chills), headache and sore throat were the other symptoms most often encountered. A pleuritic type of chest pain on deep inspiration was noted by several patients. Occasionally, there was no complaint at the time of examination although a history of respiratory tract infection in the preceding month could frequently be elicited.

Physical findings were extremely meager in the majority of cases. Several examinees showed no abnormal chest findings of any kind. The breath sounds were usually of normal character but either diminished or slightly exaggerated in intensity. Bronchial breathing was not heard. Varying grades of dullness, usually slight, were found on percussion over the affected regions. A large proportion of the cases presented râles which were sticky, subcrepitant and/or rhonchial in nature. In a number of patients a friction rub was heard in the anterolateral portion of the chest below the nipple area. Mild nasopharyngitis was commonly found, often being associated with slight enlargement of the cervical lymph glands.

Temperature, pulse, urine, leukocyte count and differential blood count were normal in the great majority of instances. Abnormalities, when present, were never marked. The highest temperature was 102° F., returning to 98° F. in three days. The highest white blood cell count recorded was 12,650 per cu. mm., with only a slight shift of the leukocytes to the left. Sedimentation rates varied between 22 and 34 mm. fall per hour (Cutler method) in the majority of cases where this procedure was performed. Sputum examinations were done in only 2 cases and showed no significant findings.

The duration of the illness was determined by the length of time required to obtain an essentially normal roentgenographic appearance of the chest. Most frequently the patients were asymptomatic a considerable time before the chest roentgenograms appeared normal. In the majority of cases the chest roentgenogram appeared essentially normal in two to four weeks. Several cases showed complete resolution in one week and in 1 patient an associated extensive pleural effusion persisted for two and a half months.

The roentgenographic appearance of thickening of the lower end of the long fissure, due to exudate and/or moderate

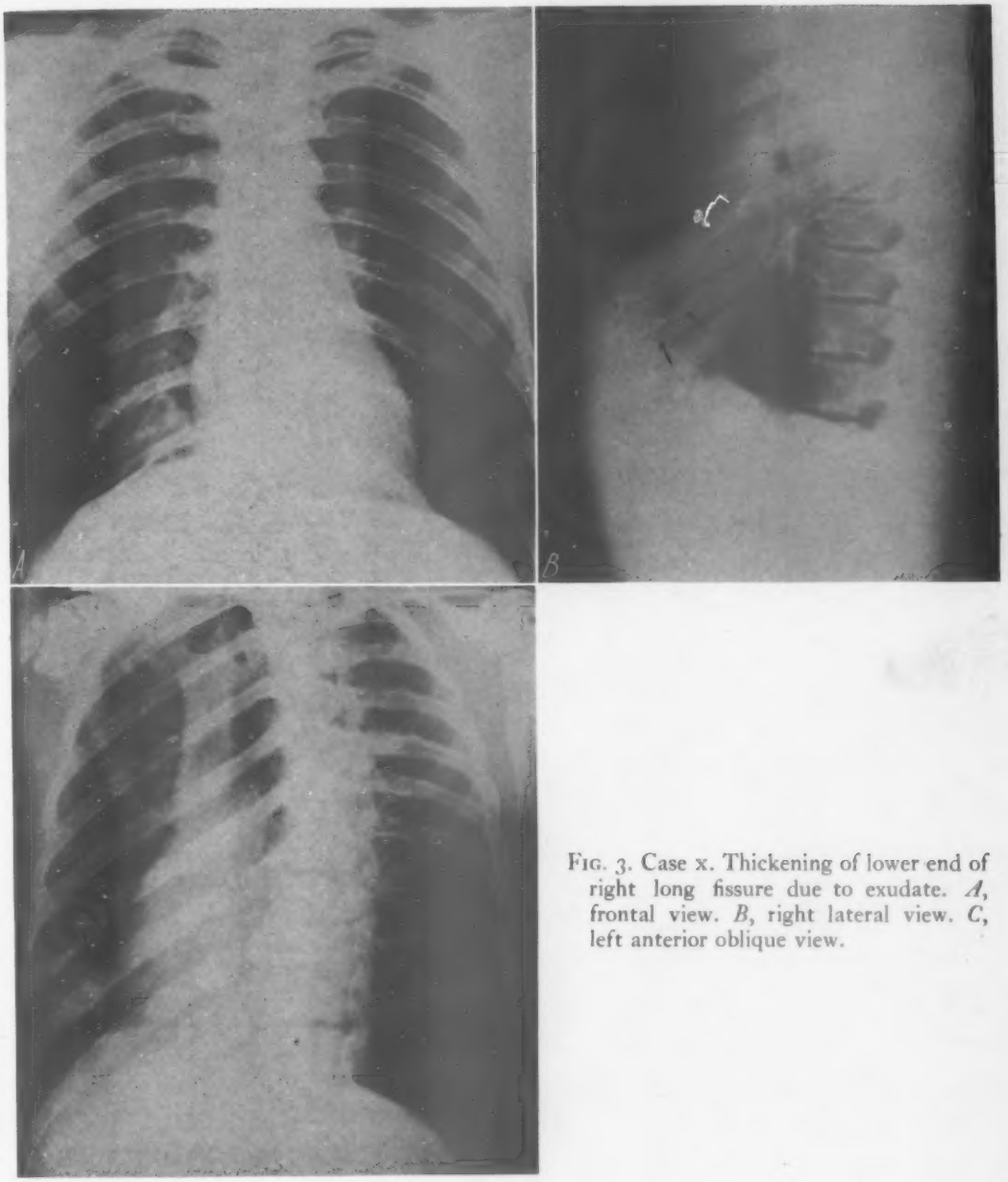


Fig. 3. Case x. Thickening of lower end of right long fissure due to exudate. *A*, frontal view. *B*, right lateral view. *C*, left anterior oblique view.

amounts of effusion, was quite characteristic. In the frontal view was seen a rather limited area of homogeneous opacity in the lower lung field, adjacent the heart, which always extended down to the diaphragm in the cardiophrenic angle (Fig. 3, 5, 6 and 7). Failure of the opacity to overlap the diaphragmatic shadow was found to be strong evidence against the diagnosis of exudate in the lower interlobar fissure. The lateral margin of the opacity was well demarcated from the surrounding pulmonic tissue and did not extend laterally beyond the midclavicular line. Fuzziness or streaking at the margins was not observed unless there was an adjacent parenchymal involvement. The density of the opacity varied with the amount of exudate or fluid that was present between the lobes. In some instances, the homogeneous haze was comparatively

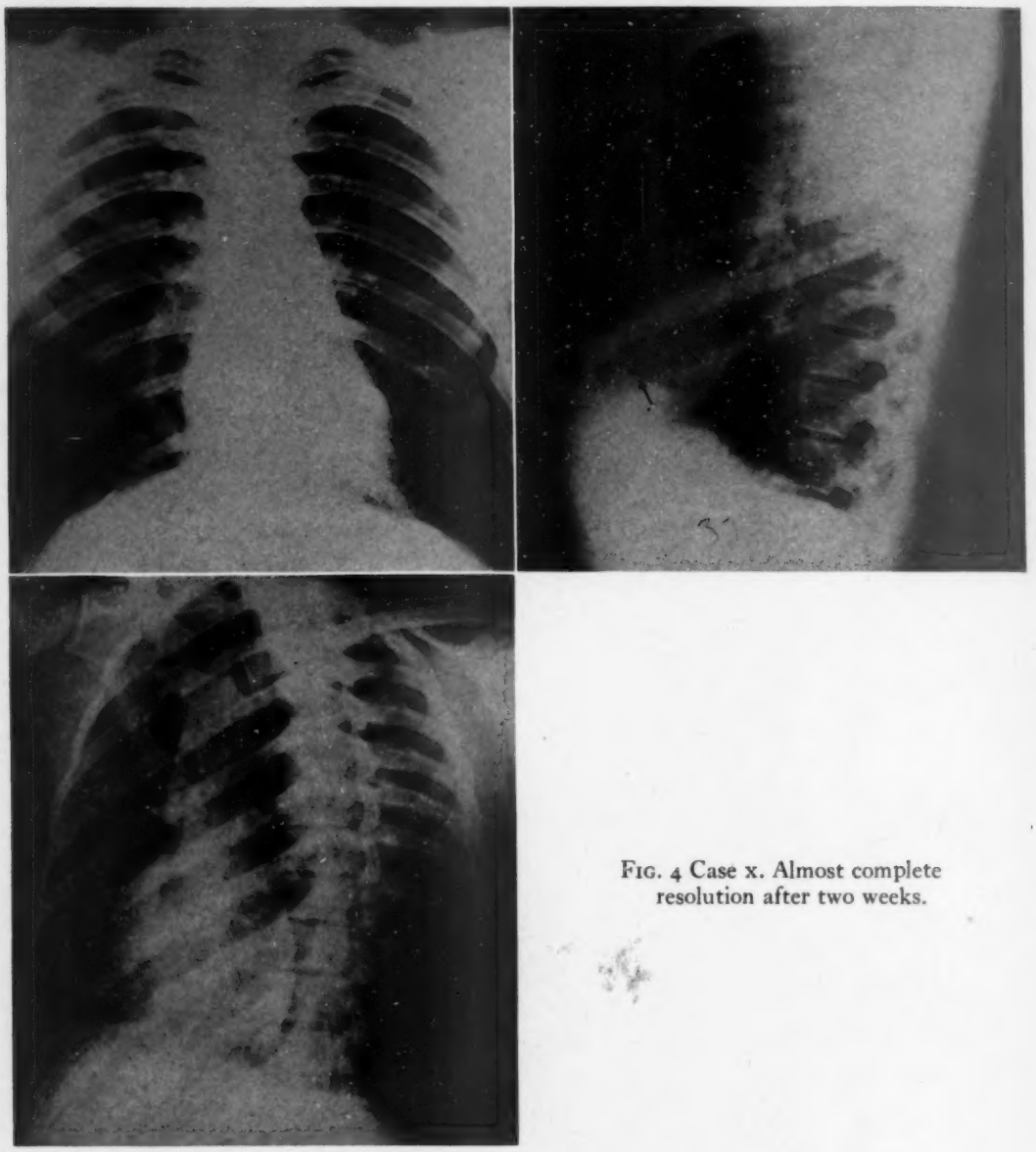


FIG. 4 Case x. Almost complete resolution after two weeks.

slight in the frontal view and quite dense in the lateral and oblique views (Fig. 7). In others, the shadow was quite opaque in the frontal view. When the lower end of the left long fissure was involved, blurring of the usually sharp left lower cardiac border was uniformly observed (Fig. 5*A*). Seen through the homogeneous moderate densities in the cardiophrenic angles were the normal, somewhat denser, pulmonary markings which coursed from the hila to the medial portions of the lower lobes behind the anteriorly located fissures. These markings were never found exaggerated in size or increased in number if only an interlobar fissure exudate was present (Fig. 3*A* and 7*A*). The presence of increased pulmonary markings in the lower lobes was always found to indicate a lower lobe pneumonic process, identified by examination in other views.

Examinations made in the lateral view clearly showed the thickening of the lower portion of the interlobar fissure. The den-

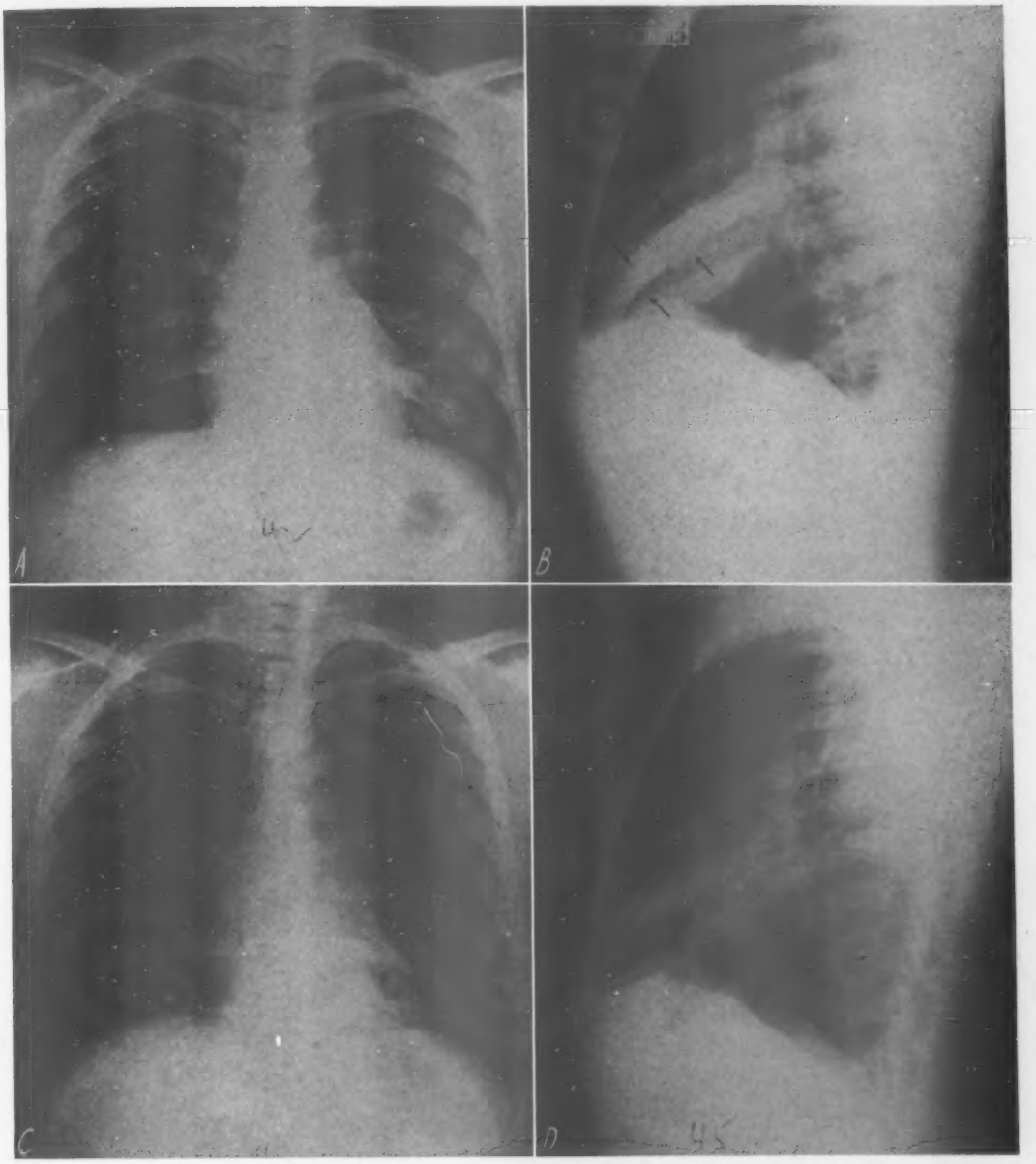


FIG. 5. Case XIII. *A*, frontal view. Note blurring of left lower cardiac margin. *B*, left lateral view. Thickening of lower end of left long fissure due to exudate. *C*, complete resolution in five weeks, frontal view. *D*, lateral view.

sity was observed in the region of the junction of the diaphragmatic shadow with that of the anterior chest wall and extended upward for a variable distance along the course of the interlobar fissure. It was band-like in appearance and varied in thickness, depending upon the amount of exudate present (Fig. 3*B*, 5*B* and 7*B*). Less frequently, fluid was present and the opacity tended to assume a typical fusiform shape (Fig. 6*B*). In the antero-inferior end of the long fissure at its junction with the diaphragm, the density was occasionally irregular and knob-like in appearance due to the pleuritic inflammatory process extending out into the anterior free pleural space be-

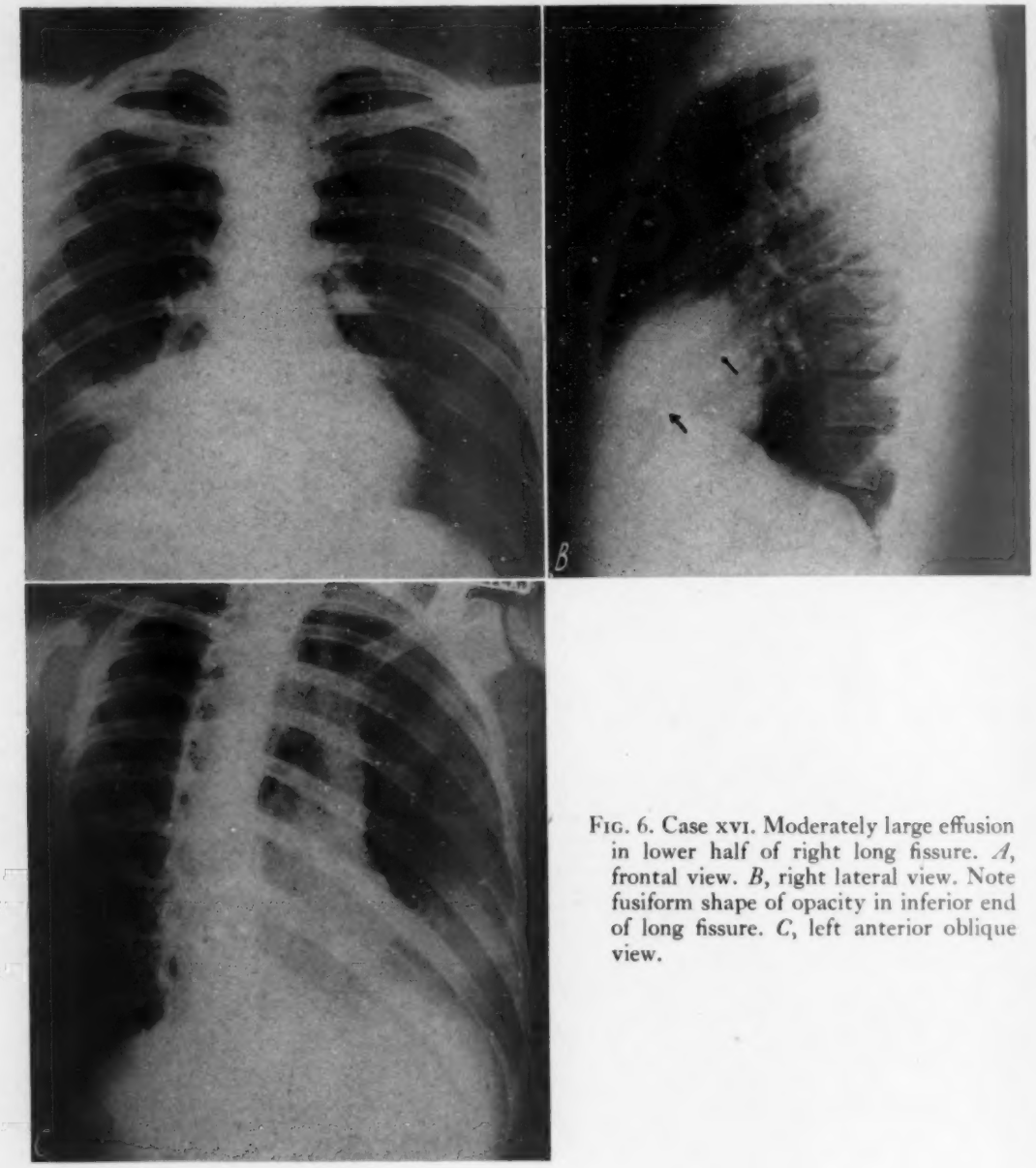


FIG. 6. Case XVI. Moderately large effusion in lower half of right long fissure. *A*, frontal view. *B*, right lateral view. Note fusiform shape of opacity in inferior end of long fissure. *C*, left anterior oblique view.

yond the end of the fissure (Fig. 3*B* and 7*B*). Occasionally, small, less opaque patchy areas of pneumonic infiltration were seen adjacent to the thickened pleura.

The appearance on the oblique roentgenograms was also characteristic. Involvement of the right lower fissure was best demonstrated in the left anterior oblique view (Fig. 3*C* and 6*C*). The thickened lower end of the long fissure was seen as a rather homogeneous, triangular opacity in the anterior portion of the right lower lung field immediately adjacent the lower right cardiac outline, and lying on the mesial half of the diaphragm. The upper side of the triangle was arc-like, convexity cephalad, and the apex was located on the diaphragm. In this view, the normal pulmonic markings of the right lower lobe were well separated from the opacity of the thickened fissure and the homogeneous appearance of the shadow was not disturbed by pulmonic

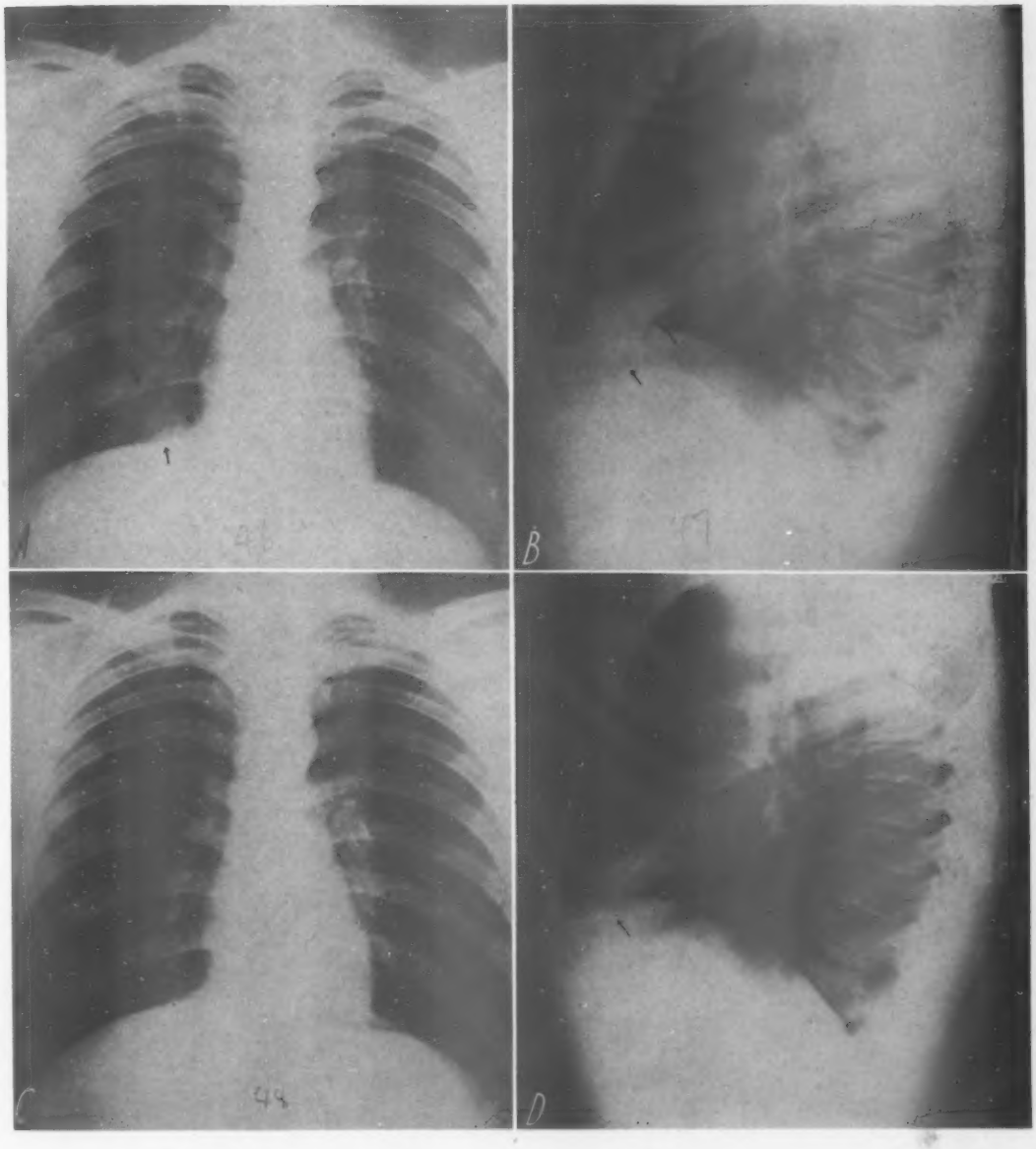


Fig. 7. Case 1. *A*, frontal view. Small opacity in right lower lung field mesially due to exudate in lower end of right long fissure. Normal pulmonary markings in this region are clearly demonstrated. *B*, right lateral view. Note knob-like density at junction of diaphragm with antero-inferior end of long fissure. *C*, same case. Resolution progressing well, frontal view. *D*, lateral view.

markings coursing through it. The right anterior oblique position was employed to demonstrate involvement of the lower portion of the left long fissure. In this view a considerable portion of the band-like opacity was situated within the denser shadow of the lower left anterior portion of the heart, and the homogeneous triangle of density due to the thickened pleura was considerably smaller than on the right side but had the same general features.

Obliteration of the costophrenic sinus by varying amounts of pleural effusion or exudate resulted in the usual characteristic appearance.

In a large number of cases, roentgenographic evidence characteristic of atypical pneumonia was found to be associated with

the pleural exudates. In some, the lesions were in the adjacent lobes, while in others, the pneumonitis was in the contralateral lung. They appeared as linear, linear and small patchy, faintly dense patchy or confluent moderately opaque infiltrations.

The average duration of the pleural exudate was from two to four weeks. Roentgenograms of the chest taken after this period usually showed complete disappearance of the originally observed opacity. Occasionally, however, light residual thickening of the involved interlobar fissure was noted. Pleural effusions persisted somewhat longer than exudative thickening of the pleura without fluid. When pleural involvement was associated with a parenchymal atypical pneumonic infiltration both processes most often resolved simultaneously. Infrequently, evidence of residual pleural thickening would persist for about ten days after the pneumonia had completely cleared. However, all of the roentgenograms showed sufficient resolution to allow the patients to resume full military duties.

DISCUSSION

It was found necessary to differentiate exudate or effusion in the lower halves of the interlobar fissures from (1) middle lobe pneumonia and/or atelectasis, (2) involvement of the lower anteromedial portion of the left upper lobe adjacent to the interlobar fissure and near the heart and (3) infiltrations in the lower lobes mesially, near or behind the heart.

Middle lobe involvements resulted in roentgenographic appearances quite similar to lower interlobar fissure exudates in the frontal view (Fig. 8*A*). However, the density of the middle lobe processes was usually considerably greater and less homogeneous, and the normal lower lobe pulmonic markings were less sharply delineated within it. Definite exclusion was obtained only on the lateral view (Fig. 8*B*). In this view the band-like or fusiform shadow of the interlobar process could be differentiated with ease from the characteristic triangular appearance of the opacified, involved middle lobe. The base of the triangle, lying against the anterior chest wall, was very much larger and extended considerably higher than the lower anterior end of the band-like opacity of the thickened interlobar fissure. The upper margin of the density of the involved middle lobe was almost horizontal, being limited by the short fissure; whereas the band-like density of the thickened long fissure extended obliquely upward and posteriorly at an angle approximating 45°.

Pneumonia located in the lower medial portions of the left upper lobe adjacent to the long fissure and near the heart also required exclusion (Fig. 8*C*). In these cases, the opacity, while occupying the lower portion of the lung field medially and blurring the cardiac border, did not extend down to the diaphragm. The margin of the density was rather sharply delineated and assumed an arc-like curve, convexity downward, with the lowest portion of the arc being adjacent to the left cardiac border. A clear triangular space of uninvolved pulmonary tissue was observed between the mesial aspect of the opacity and the diaphragm. Additional aid in differentiation was obtained from the lateral view (Fig. 8*D*). The broad area of radiodensity due to the upper lobe involvement was easily differentiated from the band-like density of the thickened fissure. The lower margin of the pneumonic process was extremely sharp, being limited by the long fissure, and formed an acute angle with the anterior end of the diaphragm. The characteristic irregular knob-like opacity of interlobar fissure involvement, clouding the angle between the lower long fissure and the diaphragm, was absent.

Lower lobe infiltrations near the heart occasionally offered difficulty in differentiation (Fig. 9*A*). However, careful observation revealed that the opacity of the cardiophrenic angle was not homogeneous. Instead, it consisted of distinctly increased pulmonary markings, with or without small patchy pneumonic infiltrations. Definite

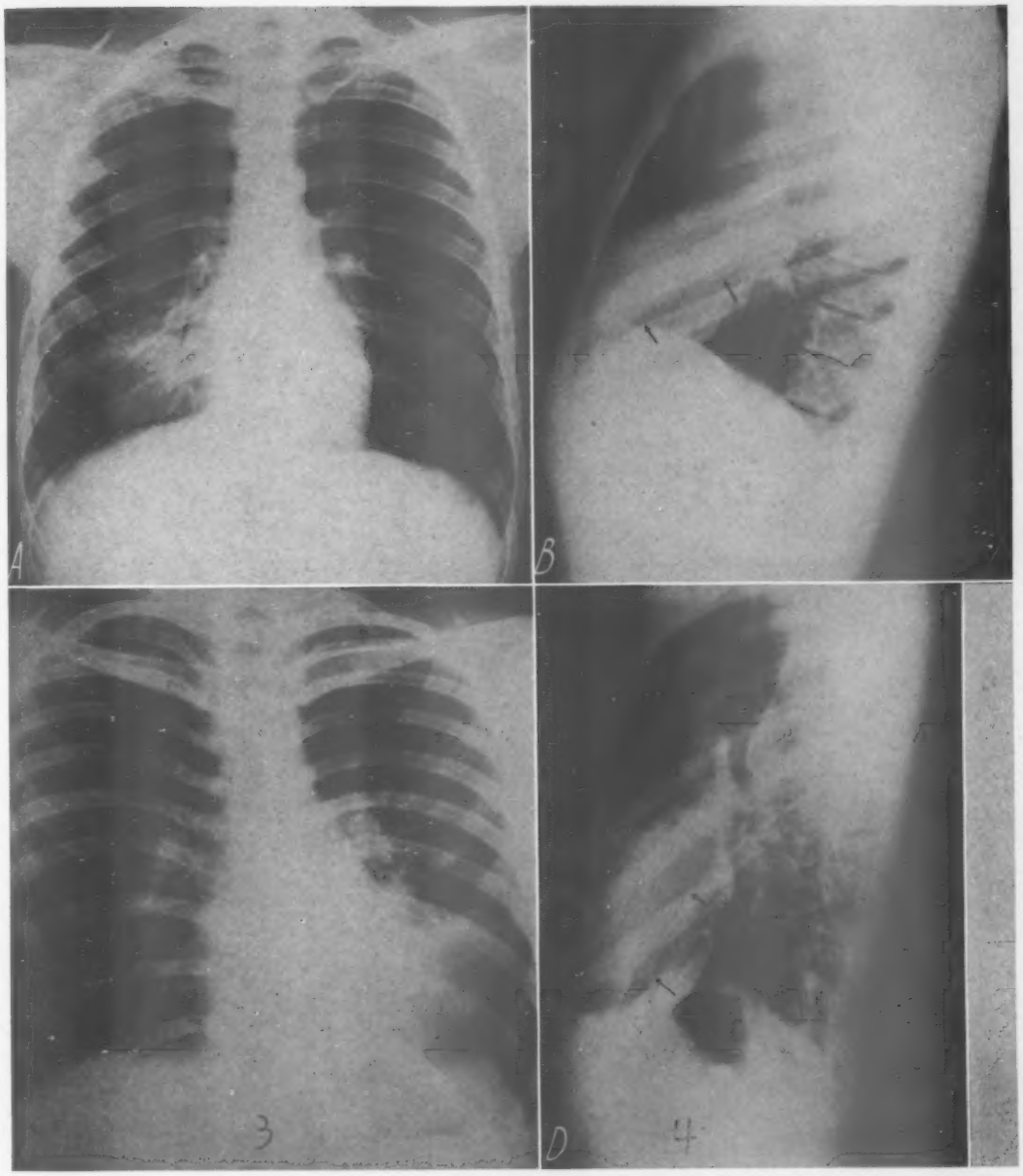


FIG. 8. *A*, pneumonia in right middle lobe. Frontal view. *B*, right lateral view. Same case as *A*. Note the triangular shape of the opacified middle lobe. *C*, pneumonia in lower mesial portion of left upper lobe adjacent to the fissure. Frontal view. *D*, left lateral view. Same case as *C*. Large area of infiltration in the lower anterior portion of the left upper lobe is well shown.

exclusion could again be obtained from the lateral and oblique roentgenograms (Fig. 9*B* and 9*C*), which showed the location of the process in the lower lobes posteriorly and the freedom from involvement of the interlobar fissure.

Inflammatory processes in the pleura, particularly of the interlobar fissures, during the course of primary atypical pneumonia have occurred in our series of cases in a much higher degree than has been reported by practically all other observers. This may have been due, in considerable extent, to the frequent employment of

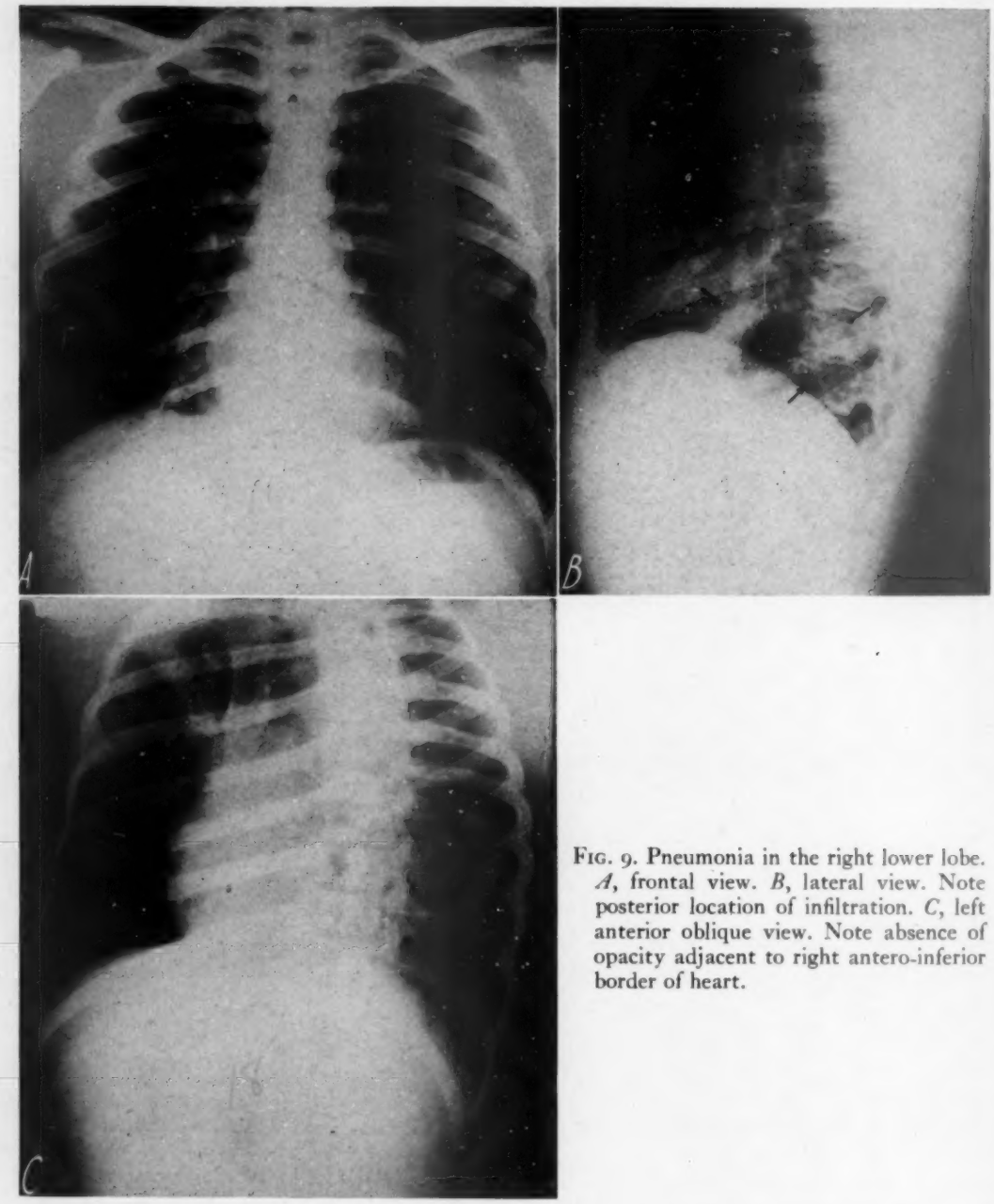


FIG. 9. Pneumonia in the right lower lobe. *A*, frontal view. *B*, lateral view. Note posterior location of infiltration. *C*, left anterior oblique view. Note absence of opacity adjacent to right antero-inferior border of heart.

lateral and oblique views in practically all cases of pneumonia, and especially whenever there was a possibility of interlobar fissure involvement. In several of the patients the definite diagnosis of interlobar thickening could be made only after additional roentgenographic examinations had been made. It was of interest that in several of the publications on atypical pneumonia containing no mention of pleural involvement, frontal roentgenograms presented as illustrations of lower lobe pneumonia had the appearance we have found characteristic of exudative pleuritis of the inferior portions of the interlobar fissures. Unfortunately, in these cases, lateral views were not shown and no mention was made of examinations having been performed in

the various positions. On the other hand, oblique and lateral views were employed by other investigators and found of considerable value.[2,8,16,18,27,33,35] Crysler,[4] who reported a similar, comparatively high incidence of pleural involvement with atypical pneumonia (22 out of 178 cases), stressed the importance of the lateral projection in the diagnosis of pleural thickening.

The occurrence of an associated pleuritic inflammatory process was found to have no apparent influence on the clinical course of the disease in these ambulatory cases. Of the 21 patients with pleural involvement 20 had symptoms and signs no more severe than the remaining 123 cases with atypical pneumonia who showed no evidence of involvement. The only moderately severe case clinically was the patient with an extensive effusion in the general pleural space. There was no mortality or severe complication in this series.

CONCLUSIONS

1. Of 144 ambulatory cases of primary atypical pneumonia 21 (14.5 per cent) demonstrated definite roentgenographic evidence of involvement of the pleura. The majority of these cases showed thickening of the lower ends of the long fissures probably due to exudate. Roentgenographic reexamination revealed that these abnormal pleural shadows disappeared usually in two to four weeks, a short time after the complete clinical recovery of the patients.

2. The distinctive roentgenographic features of these cases are described. Differential diagnosis is discussed and the importance of lateral and oblique views is stressed.

3. The clinical course of the patients appeared to be essentially the same as corresponding cases of atypical pneumonia without pleural involvement.

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AN EVALUATION OF TELEROENTGENOGRAPHIC MENSURATION AND CARDIAC ROENTGENOSCOPY IN THE DIAGNOSIS OF EARLY MITRAL VALVE DISEASE*

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EARLY roentgenologic recognition of cardiac enlargement is desirable because a definite diagnosis of heart disease may depend on this information. To achieve this, Hodges and Eyster presented charts correlating the cardiac surface area[5] and transverse diameter[4] with patients' heights and weights. In 1939, Ungerleider and Clark[11] published a prediction chart for the transverse diameter of the heart in relation to normal patients' heights and weights based on teleroentgenographic mensuration. Ungerleider and Gubner[13] later presented a nomogram to determine the actual cardiac surface area from teleroentgenograms for comparison with predicted average cardiac surface areas established in relation to normal individuals' heights and weights. Ungerleider, Duhigg and Gubner[12] stated that teleroentgenograms were the most practical method of determining heart size, but clearly indicated that the best way to determine chamber enlargement was by means of cardiac roentgenoscopy.

Newcomer and Newcomer[7] reported that cardiac enlargement could be estimated by computing the ratio of the heart rectangle to the lung rectangle as measured teleroentgenologically. Patients' heights and weights were not taken into consideration, although allowance was made for the various types of hearts. Ratios over 27 per cent were believed to represent definite enlargement.

Ungerleider and Gubner[13] agreed that this was a reliable method when information as to heights and weights was lacking. They also remarked that under such conditions cardiac enlargement might be estimated from the relationship of the lower left cardiac border to the mid-clavicular line.[2] The unreliable nature of the latter procedure was indicated by them later in a case reported in 1943 in which the apex was within the mid-clavicular line despite obvious cardiac enlargement.[12]

Comeau and White[1] ascribed some value to the cardiothoracic ratio in following individual cases. Nevertheless, they recommended its replacement by prediction tables, which they regarded as more reliable and equally simple. They stressed the fact that although a majority of patients with significant cardiac enlargement could be defined by mensuration, there was no reliable method of determining how many people with slight or moderate cardiac enlargement were included within the established normal limits.

Levy, Stroud and White[6] reported that the most frequent cause for the rejection of men for military service was rheumatic mitral valve disease. Roentgenologically, they found the Hodges and Eyster formula inadequate, and they concluded that height and weight alone did not indicate important variations in normal body build, and that no criteria yet introduced adequately covered the range of the normal heart.

The first recognizable change in the size of the heart due to mitral valve disease is enlargement of the left auricle which may occur before the other chambers are affected. Sosman[10] considered such dilatation indicative of mitral stenosis even in the absence of typical auscultatory findings. According to Parkinson[8] the demonstration of an enlarged left auricle is second in importance only to the characteristic murmurs in the diagnosis of mitral stenosis.

* From the Radiologic Service of M. G. Wasch, M.D., The Jewish Hospital of Brooklyn, Brooklyn, N. Y.

TABLE I

TELEROENTGENOGRAPHIC MENSURATION AND CARDIAC FLUOROSCOPY IN DIAGNOSIS OF EARLY MITRAL VALVE DISEASE

Case No.	Age (yr.) and Sex	Clinical Diagnosis	Murmurs	Actual Transverse Diameter of Heart mm.	Predicted Transverse Diameter from Chart mm.	Predicted Transverse Diameter from Nomogram mm.	Actual Surface Area from Nomogram sq. cm.	Predicted Surface Area from Nomogram sq. cm.
1	10 F	Mitral stenosis and insufficiency	Short presystolic, long loud systolic at apex	108	106	106	82	88
2	12 M	Mitral insufficiency	Long, loud apical systolic transmitted to axilla	115	116	117	101	100
3	12 F	1937—functional murmur 1939—murmur louder, transmitted to walls 1942—mitral insufficiency	Short apical systolic Persistent loud systolic at apex, transmitted to axilla	108	121	121	93	104
4	12 M	Mitral insufficiency	Loud, high pitched apical systolic transmitted to axilla	114	114	112	94	96
5	13 F	Mitral insufficiency	Systolic at apex transmitted to axilla; ? diastolic; definite diastolic heard two years later	118 (1937) 108 (1940)	121 (1937) 125 (1940)	121 (1937) 125 (1940)	101 (1937) 104 (1940)	105 (1937) 108 (1940)
6	16 M	Mitral insufficiency	Rough, loud systolic at apex transmitted to axilla	120	127	127	128	118
7	17 F	Mitral stenosis and insufficiency	Systolic and diastolic at the apex	120	120	120	106	121
8	17 M	Mitral stenosis and insufficiency; aortic insufficiency	Systolic and diastolic at apex, diastolic along left sternal border	112	Height and weight not available			
9	17 F	? Mitral insufficiency	Systolic at apex and pneumonic area: ? apical diastolic	115	Height and weight not available			
10	17 M	Mitral insufficiency and stenosis	Long blowing apical systolic and diastolic	122	119	119	120	108
11	18 M	1927—mitral stenosis and insufficiency 1938—functional	Rough blowing apical systolic and diastolic Soft apical systolic, not transmitted	110	117	117	110	110
12	18 F	Subacute bacterial endocarditis; mitral insufficiency	Loud harsh systolic at apex, no diastolic	103	117	117	109	108
13	20 F	Mitral stenosis and insufficiency	Systolic and diastolic at apex	105	Height and weight not available			
14	21 F	Mitral stenosis	Short basal systolic, long apical diastolic	127	133	134	121	121
15	22 F	Ulcerative colitis, mitral stenosis and insufficiency	Rough systolic and short diastolic at apex	103	Height and weight not available			
16	22 F	Mitral stenosis and insufficiency	Systolic and presystolic at apex	110	121	122	120	108
17	23 M	Mitral stenosis and insufficiency	Systolic and presystolic at apex	137	142	142	138	130
18	23 F	Possible mitral insufficiency	Systolic at apex	122	118	118	110	112
19	25 M	Mitral stenosis and insufficiency	Systolic and diastolic at apex	143	Height and weight not available			

Table I—*Continued*

Heart Rectangle / Lung Rectangle Ratio Per Cent	Cardiac Enlargement from Measurements	Enlarged Left Auricle	Change in Heart Contour	Comment		
				History of Rheumatic Fever	Duration of Known Heart Disease	Period of Observation
25	None	++	None	Yes	6 yr.	
27	None	++	None	Yes	6 yr.	4 yr.; no change
25	None	++	None	No	6 yr. (?)	5 yr.
27	None	++	None	Yes	6 yr.	Death from subacute bacterial endocarditis; autopsy revealed slight mitral insufficiency
26 (1937) 24 (1940)	None None	++ ++	None	Yes	3 yr.	3 yr.
22	? None	++	None	Yes	5 yr.	2 yr.
27	None	++	None	No	Unknown	—
25		++	None	Yes	7 yr.	—
26		++	Prominent pulmonary artery	No	Unknown	—
27	None	++	None	No	7 yr.	2 yr.
25	None	++	None	?	11 yr. (?)	11 yr.
18	None	++	None	?	16 yr.	Dead. Autopsy revealed mitral stenosis and dilated left auricle
26		++	None	?	9 yr.	9 yr.; murmurs persisted
26	None	++	None	Yes	7 yr.	—
23		++	None	Yes	8 yr.	Autopsy—mitral endocarditis with dilated left auricle
25	None	++	None	Yes	15 yr.	5 yr.
23	None	++	Straightened left border	?	6 yr.	6 yr.
25	None	++	None	?	?	24 yr.
23		++	None	None	Unknown	—

TABLE 1—*Continued*

TELEROENTGENOGRAPHIC MENSURATION AND CARDIAC FLUOROSCOPY IN DIAGNOSIS OF EARLY MITRAL VALVE DISEASE

Case No.	Age (yr.) and Sex	Clinical Diagnosis	Murmurs	Actual Transverse Diameter of Heart mm.	Predicted Transverse Diameter from Chart mm.	Predicted Transverse Diameter from Nomogram mm.	Actual Surface Area from Nomgram cm.	Predicted Surface Area from Nomogram sq. cm.
20	25 F	Mitral stenosis and insufficiency	Systolic and diastolic at apex	130	Height not available			
21	25 F	Mitral stenosis and insufficiency	Systolic and presystolic at apex	141	137	137	102	108
22	26 F	Mitral stenosis and insufficiency	Systolic and diastolic at apex	110	Height and weight not available			
23	26 F	Mitral stenosis and insufficiency	Rough loud presystolic	110	Height not available			
24	26 F	Mitral stenosis and insufficiency	Rough systolic and presystolic at apex	124	122	122	98	110
25	26 F	Mitral stenosis and insufficiency	Rough systolic and presystolic at apex transmitted to axilla	132	117	117	106	104
26	28 F	Possible heart disease	Systolic at apex	117	117	117	104	98
27	29 F	Possible heart disease	Systolic at apex	135	131	130	98	102
28	33 M	Mitral stenosis and insufficiency	Systolic and diastolic at apex	112	Height and weight not available			
29	33 M	Mitral insufficiency	Presystolic at apex	115	Height not available			
30	34 F	Mitral stenosis and insufficiency	Systolic and presystolic at apex	110	Height not available			
31	34 F	Mitral stenosis and insufficiency	Systolic and diastolic at apex	114	113	113	101	116
32	39 F	Mitral stenosis and insufficiency	Loud apical diastolic with snapping first sound	113	128	128	112	105
33	39 F	Mitral stenosis and insufficiency	Systolic and diastolic at apex	110	Height and weight not			
34	41 F	Mitral stenosis and insufficiency	Loud presystolic and systolic at apex	113	Height and weight not available			
35	42 F	Mitral stenosis	Rough low pitched mid-diastolic and presystolic	120	135	140	104	94
36	42 F	? Heart disease	Short systolic at apex transmitted to axilla	138	133	133	122	122
37	42 F	Mitral stenosis and insufficiency; aortic insufficiency	Loud systolic and rough diastolic at apex, loud systolic at aortic	136	122	123	114	103
38	49 F	Mitral stenosis and insufficiency; aortic insufficiency	Loud rough apical systolic and diastolic, basal systolic	115	Height and weight not available			
39	54 F	Mitral stenosis and insufficiency; aortic insufficiency	Systolic and diastolic at apex, basal systolic	112	Highest and weight not available			
40	56 F	Mitral stenosis and insufficiency	Long apical diastolic	127	125	123	100	112

Table I—*Continued*

Heart Rectangle / Lung Rectangle Ratio Per Cent	Cardiac Enlargement from Measurements	Enlarged Left Auricle	Change in Heart Contour	Comment		
				History of Rheumatic Fever	Duration of Known Heart Disease	Period of Observation
23		++	None	Yes	11 yr.	2 yr.
27	None	++	None	Yes	18 yr.	5 yr.
24		++	None	No	4 yr.	4 yr.
25		++	None	?	2 yr.	—
23	None	++	None	Yes	4 yr.	4 yr.
22	None	++	None	No	?	1 yr.
25	None	++	None	No	?	—
26	None	++	None	No	9 yr.	—
23		++	None	Yes	3 yr.	2 yr.
22		++	None	No	Unkown	—
25		++	None	No	5 yr.	5 yr.
26	None	++	None	Yes	More than 20 yr.	—
24	None	++	None	Yes	More than 20 yr.	—
25	None	++	None	Yes	20 yr.	—
25		++	None	Yes	More than 20 yr.	—
21	None	++	None	None	Unknown	3 yr.
29	? From $\frac{\text{heart}}{\text{lung}}$ rectangle	++	None	Yes	Unknown	—
27	? From predicted transverse diameter	++	Prominent left border	?	Unknown	3 yr.
25		++	Prominent left border	Yes	18 yr.	—
25		++	None	Yes	More than 30 yr.	—
27	? from surface area nomogram	+++	Prominent left border	Yes	21 yr.	Autopsy—mitral stenosis with large ball-valve thrombus in left auricle.

Thus far the criteria most frequently used for estimating cardiac enlargement are based on teleroentgenographic mensuration. These do not take into consideration the fact that posterior enlargement of the left auricle may occur without altering the frontal silhouette of the heart. Teleroentgenographic mensuration was found to be of little value in the diagnosis of early mitral valve disease in children, but demonstration of enlargement of the left auricle in the right anterior oblique projection was very important, particularly in the absence of classical murmurs.[3]

In this communication 40 patients with early but indisputable mitral valve disease are reviewed from the roentgenologic viewpoint. The various methods of teleroentgenographic mensuration proposed by Ungerleider and Clark and Ungerleider and Gubner were used and the findings compared with roentgenologic observations for left auricular dilatation. The heart rectangle:lung rectangle ratios were calculated and the relationship of the apex of the heart to the left mid-clavicular line was determined.

MATERIAL AND FINDINGS

There were 9 men and 31 women from ten to fifty-four years old in this group. All but 4 were ambulatory at the time of roentgenologic examination. Each patient was examined roentgenoscopically, by means of posteroanterior teleroentgenograms and right anterior oblique views made after swallowing a bolus of barium paste.

The barium paste was made by adding a heaping tablespoon of chocolate barium preparation to a quarter of a glass of water and stirring vigorously until a thick, smooth creamy consistency was obtained. The patient was given a swallow of paste after being placed in approximately the correct position, and roentgenoscopic observations were made during suspended respiration and deep inspiration. Roentgenograms were made at the end of a moderate inspiration, permitting a few seconds to elapse after the patient had swallowed his mouthful of barium paste. For survey purposes an angle of from 75 to 85 degrees in the right anterior oblique position should be adequate.

The normal right anterior oblique roentgenogram of the esophagus presents a straight opaque line posterior to the cardiac silhouette. Early left auricular enlargement usually results in an indentation into the anterior aspect of the barium column at the proper level. This is visible only in the right anterior oblique position approximately in the middle third of the esophagus because the degree of enlargement at that time is usually insufficient to shift the esophagus from left to right laterally.

Occasionally patients were encountered in whom there was a gentle sloping arc of displacement of the barium-filled esophagus. These were considered to be within normal limits. Difficulty also arose in some patients with tortuous and dilated aortas, in whom the esophagus was drawn to the left and posteriorly. In these the right anterior oblique projection of the esophagus may simulate enlargement of the left auricle.[9] Enlargement of the left auricle was diagnosed only when there was a localized indentation at the proper level which persisted during deep inspiration.

Twenty-one patients had known histories of rheumatic fever and 7 had histories suspicious of rheumatic fever. The duration of known heart disease varied from a few months to over twenty years. Six were followed for two years, 10 for three to five years, 2 from six to ten years and 1 for eleven years. Four patients came to postmortem examination.

Twenty-nine patients had characteristic apical systolic and diastolic murmurs, and 11 had loud apical systolic murmurs transmitted to the axilla. In most of the patients who were followed the auscultatory signs of mitral valve disease persisted unchanged or increased in intensity. In 4 there was recession of the murmurs so that at one time or another the clinical diagnosis had been changed to functional heart murmurs. There is little doubt that the mitral lesions

in these individuals were persistent even though the clinical signs varied.

Electrocardiographic examinations were available in 22 patients. Prolonged auriculoventricular conduction times were present in 2, and 2 others had auricular fibrillation. All the remaining patients had normal electrocardiographic findings.

All 40 patients had visibly enlarged left auricles as indicated by posterior deviation of the barium-filled esophagus in the right anterior oblique projection. No visible deviation of the esophagus was apparent in the posteroanterior view. There were no other signs of left auricular dilatation. The position of the bronchi was unchanged and the left auricle did not appear on the right cardiac border. Straightening of the second left cardiac border occurred occasionally, but the characteristic "mitral heart" deformity was conspicuous by its absence. In 3 patients slight left ventricular enlargement was diagnosed.

The heights and weights of 25 patients were available. Teleroentgenographic mensuration of these was within normal limits both as to predicted and actual transverse cardiac diameters and predicted and actual cardiac surface areas in all but 2 patients (Cases 37 and 40).

The heart rectangle:lung rectangle ratio did not exceed 27 per cent nor did the apex of the heart protrude beyond the midclavicular line in any of the patients.

The 4 patients who came to postmortem examination are reported in further detail.

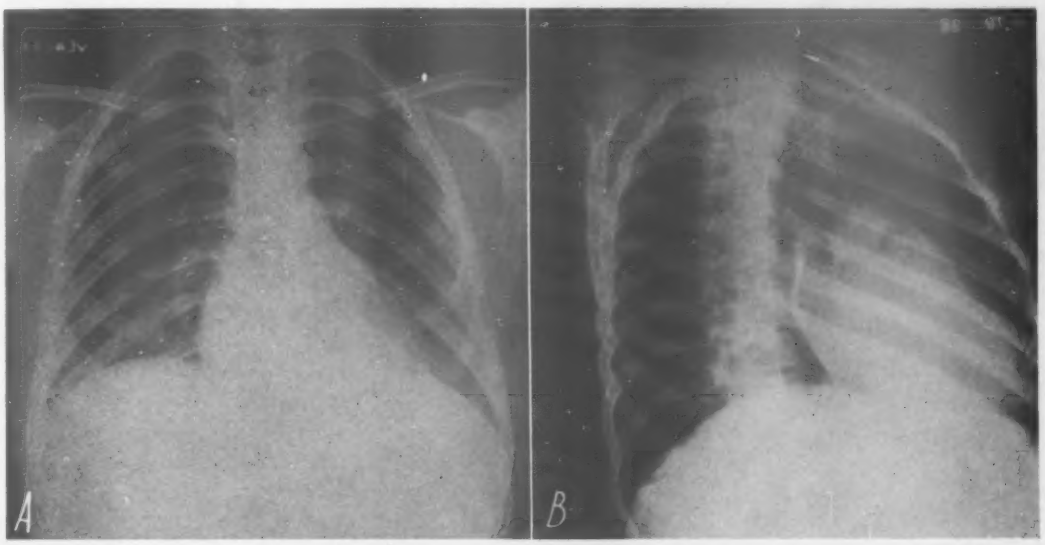

FIG. 1. Case 4. *A*, teleroentgenogram of a twelve year old boy 5 feet tall weighing 108 pounds. Actual transverse cardiac diameter 112 mm., predicted transverse diameter 114 mm. Predicted surface area 96 sq. cm., actual surface area 94 sq. cm. Heart rectangle:lung rectangle ratio 27 per cent. *B*, right anterior oblique roentgenogram of the esophagus showing slight but definite posterior displacement indicative of left auricular dilatation. See text for details of history.

REPORT OF CASES

CASE 4. I. B., a boy, aged twelve, had rheumatic fever at the age of six years. Cardiac involvement was diagnosed at that time. He was symptom free thereafter and was observed for the next six years in the out-patient department. He was active and developed normally. A loud blowing apical systolic murmur transmitted to the axilla was present at all examinations.

Joint pains recurred for three weeks six months before admission to the Hospital. He complained of periumbilical cramps for three weeks and his temperature rose to 103° F. Physical examination revealed a high pitched apical systolic murmur transmitted to the axilla. The second pulmonic sound was accentuated. A few

Fig. 2. Case 12. Teleroentgenogram of an eighteen year old girl 65 inches tall weighing 122 pounds. Actual transverse cardiac diameter 103 mm., predicted transverse diameter 117 mm. Predicted surface area 108 sq. cm., actual surface area 109 sq. cm. Heart rectangle: lung rectangle ratio 18 per cent. Roentgenoscopic examination showed definite left auricular enlargement. See text for details of history.

days later petechiae were found in his conjunctivae and over his hands and feet. His spleen was not palpable. Blood cultures were positive for *Streptococcus viridans*. Electrocardiographic examination was negative.

At the time of roentgenologic examination he was 60 inches tall and weighed 108 pounds. A teleroentgenogram did not show any gross cardiac enlargement. Roentgenoscopically early left auricular dilatation and slight left ventricular enlargement posteriorly was noted. The predicted transverse cardiac diameter was 114 mm., the actual transverse diameter was 112 mm. The predicted cardiac surface area was 96 sq. cm., the actual surface area was 94 sq. cm. The heart rectangle: lung rectangle ratio was 27 per cent. The apex was within the mid-clavicular line.

At autopsy the heart weighed 350 grams. The left ventricle was 1.0 cm. thick, the right ventricle 0.25 cm. thick. The circumference of the mitral ring was 11 cm., that of the tricuspid ring 10 cm. The aortic and pulmonic rings measured 6.5 cm. The mitral valve was distorted, mitral stenosis and insufficiency being evident. Vegetations were seen on the leaflets extending on to the left auricular endocardium. The left ventricle and left auricle were hypertrophied and dilated. Microscopically there was evidence of active rheumatic carditis.

Case 12. M. W., a girl, aged eighteen, was known to have had rheumatic fever at the age of two and a half years. Since then she had been able to indulge in the usual pastimes and perform the usual tasks of growing girls. Physical examination in 1941 revealed a loud blowing apical systolic murmur transmitted to the axilla. This was unchanged in March and May, 1942.

She was admitted to the Hospital in May, 1942, because of fever, chills and embolic phenomena. Repeated blood cultures were positive for *Streptococcus viridans*.

Teleroentgenographic examination of her chest in March, May, August and September, 1942, showed a normal heart silhouette. Cardiac roentgenoscopy during September, 1942, revealed definite posterior displacement of the barium-filled esophagus indicative of left auricular dilatation.

At the time of roentgenologic examination she weighed 122 pounds and was 65 inches tall. The predicted transverse cardiac diameter was 117 mm., the actual transverse diameter 103

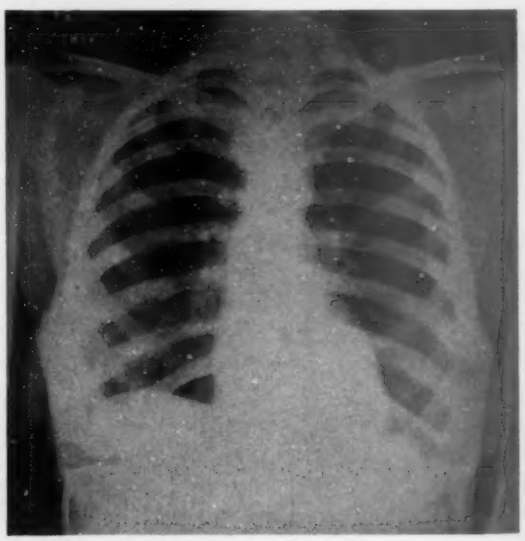

Fig. 3. Case 15. Teleroentgenogram of a twenty-two year old woman, height and weight unknown. Heart rectangle: lung rectangle ratio 23 per cent. No change in heart silhouette, but definite left auricular dilatation was found at postmortem examination.

mm. The predicted cardiac surface area was 108 sq. cm., the actual surface area 109 sq. cm. The heart rectangle: lung rectangle ratio was 18 per cent. The apex was within the mid-clavicular line.

At autopsy her heart weighed 140 grams. The left ventricle was 1.0 cm. thick, the right ventricle 0.3 cm. thick. The left auricle was dilated. The mitral valve was stenotic and fresh and old vegetations were present over the entire valve. The chordae tendineae were shortened, thickened and fused. The other heart chambers were normal.

Teleroentgenographic examination of her chest showed no change in the appearance of the heart shadow. The heart rectangle: lung rectangle ratio was 23 per cent. The apex was within the mid-clavicular line. Her height and weight were not available.

At autopsy her heart weighed 190 grams. The left auricle was dilated, the heart otherwise was not enlarged. The mitral leaflets were thickened; vascularized and healed thrombotic masses were present at their tips. Mitral insufficiency was present. The aortic valve cusps were thickened, but the valve was competent.

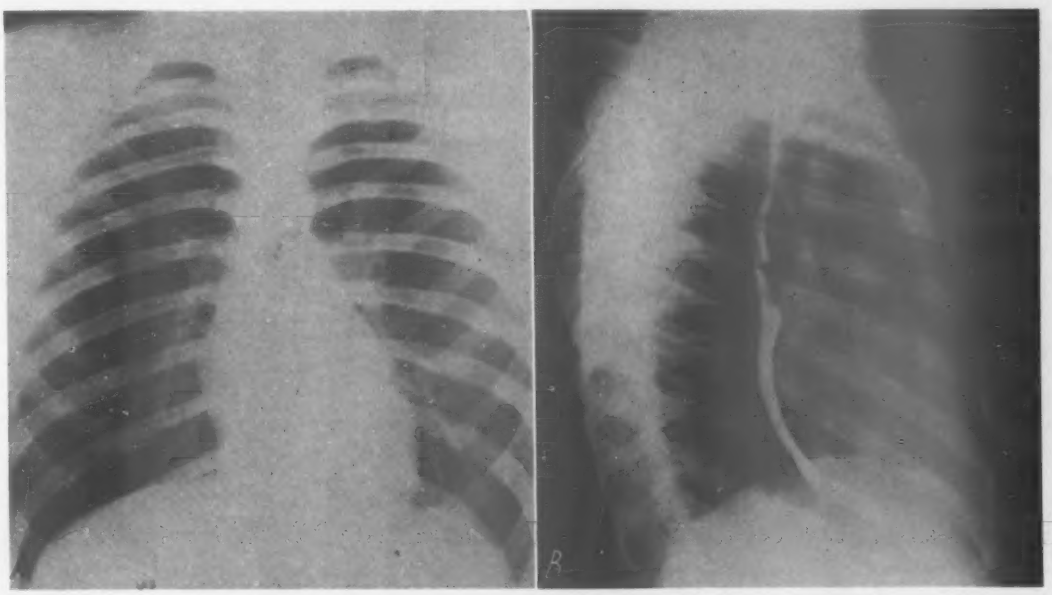

FIG. 4. Case 6. *A*, teleroentgenogram of a sixteen year old boy, 67 inches tall weighing 150 pounds. Actual transverse diameter 120 mm., predicted transverse diameter 127 mm. Predicted surface area 118 sq. cm., actual surface area 128 sq. cm. Heart rectangle:lung rectangle ratio 22 per cent. Rough loud apical systolic murmur transmitted to the axilla. *B*, right anterior oblique roentgenogram of the esophagus showing posterior deviation indicative of left auricular enlargement.

CASE 15. B. S., a female, aged twenty-two, had diarrhea with blood and mucous rectal discharges for six months before admission to the Hospital. Proctoscopic and roentgenographic examinations confirmed the diagnosis of acute ulcerative colitis, and a biopsy revealed chronic and acute proctitis.

Her cardiac condition was discovered eight years ago during her first attack of rheumatic fever. There had been no symptoms referable to her cardiac or rheumatic status since then. Characteristic systolic and diastolic murmurs were audible at the apex.

CASE 40. A. S., a female, aged fifty-six, had rheumatic fever thirty-six years ago and cardiac involvement was diagnosed at that time. Nevertheless she had been able to lead an active life.

For two years before admission to the Hospital she had dyspnea on exertion which responded to digitalization and diuretics. Auricular fibrillation had been present from that time on.

She was admitted because of right upper quadrant pain, distention, gaseous eructations and constipation. On physical examination systolic and diastolic murmurs characteristic of

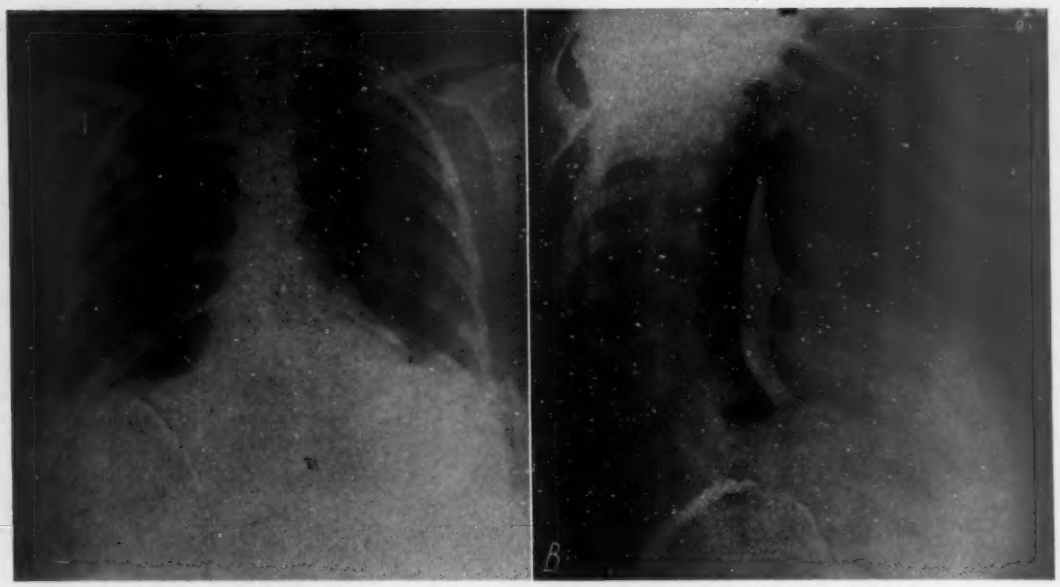

Fig. 5. Case 35. *A*, teleroentgenogram of a forty-two year old woman 61 inches tall weighing 178 pounds. Actual transverse cardiac diameter 120 mm., predicted transverse diameter 135 mm. Actual surface area 104 sq. cm., predicted surface area 94 sq. cm. Heart rectangle:lung rectangle ratio 21 per cent. Rough low-pitched mid-diastolic and presystolic apical murmurs. *B*, right anterior oblique roentgenogram of the esophagus showing posterior deviation of the barium-filled esophagus indicative of left auricular enlargement.

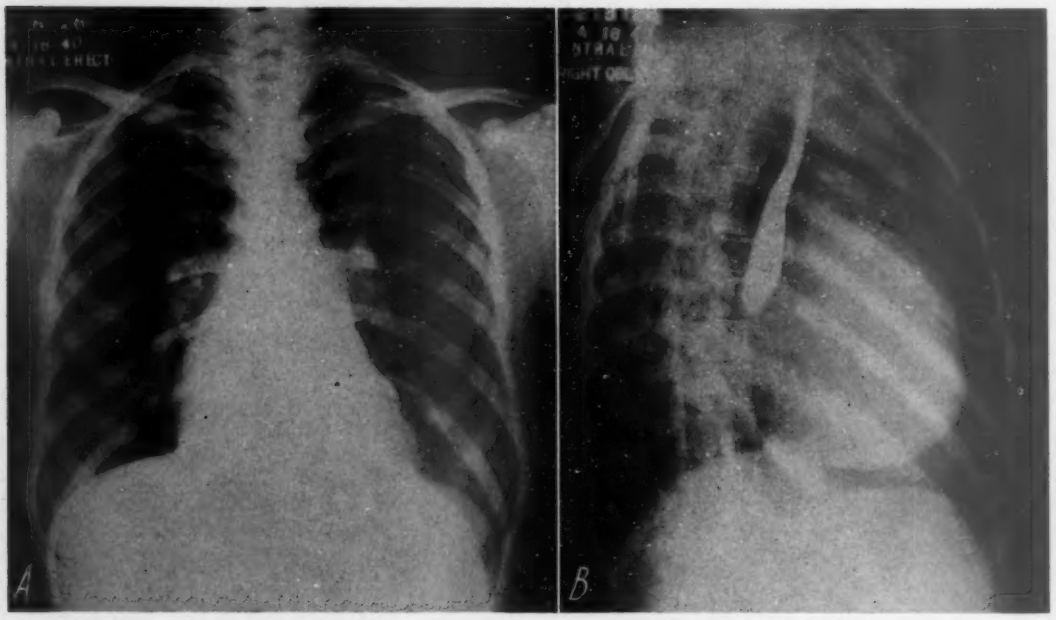

Fig. 6. Case 40. *A*, teleroentgenogram of a fifty-six year old woman 61 inches tall weighing 122 pounds. Actual transverse cardiac diameter 127 mm., predicted transverse diameter 123 mm. Actual surface area 132 sq. cm., predicted surface area 100 sq. cm. indicating cardiac enlargement. Heart rectangle:lung rectangle ratio 27 per cent. *B*, right anterior oblique roentgenogram of the esophagus showing deep indentation indicative of considerable left auricular dilatation.

mitral disease were heard. There was a moderate secondary anemia. Occult blood was found in her stool.

Roentgenologic examination of the gastrointestinal tract revealed a malignant condition of the pylorus.

A chest teleroentgenogram showed straightening of the second left heart border. There was considerable dilatation of the left auricle posteriorly. Slight enlargement of the left ventricle was present.

At the time of roentgenologic examination she weighed 125 pounds and was 61 inches tall. The predicted transverse cardiac diameter was 125 mm., the actual transverse diameter 127 mm. The predicted cardiac surface area was 100 sq. cm., the actual surface area was 132 sq. cm., indicating cardiac enlargement. The heart rectangle: lung rectangle ratio was 27 per cent.

She died after subtotal gastrectomy. At autopsy her heart weighed 430 grams. The left ventricle was 1.2 cm. thick, the right ventricle 1.0 cm. thick. The left auricle was considerably dilated and contained a large friable gray-red thrombus measuring 8 by 5 by 3 cm. The mitral orifice was small and stenotic. The papillary muscles were shortened, thickened and fused. The lungs were normal. On reviewing the roentgenograms after postmortem examination a crescentric line could be identified just within the right heart border corresponding to the location of the intra-auricular thrombus.

SUMMARY

1. In the early stages of mitral valve disease the heart may retain its normal size and contour in the frontal projection. Enlargement of the left auricle may be the only chamber affected, and this may be visible only in the right anterior oblique projection. If teleroentgenograms alone are used for roentgen examination in doubtful cases avoidable errors may occur.

2. Prediction tables based on patients' heights and weights, the heart rectangle: lung rectangle ratio, and the relationship of the apex to the left mid-clavicular line did not prove reliable in the diagnosis of early mitral valve disease in the group of patients reported here.

3. Patients with suspicious rheumatic histories or apical murmurs should be investigated routinely for left auricular enlargement. A diagnosis of a functional heart murmur should not be made in the presence of an enlarged left auricle.

4. As shown by two patients who came to postmortem examination mitral valve disease may exist for a long time without increase in the size of the heart other than left auricular dilatation.

5. As shown by the other two patients who came to postmortem examination ventricular hypertrophy may exist without being definitely identified by means of teleroentgenographic mensuration.

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ELONGATION AND TORTUOSITY OF THE DESCENDING AORTA IN A CASE OF RIGHT AORTIC ARCH, SIMULATING A RIGHT-SIDED PULSATING MEDIASTINAL MASS

By MARTIN SZABADOS, M.D.
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A WHITE farmer, aged fifty-eight, presenting the history of chronic duodenal ulcer, appeared for gastrointestinal examination. He has had some shortness of breath on exertion since childhood. No other history was elicited with reference to the cardiovascular system. The remainder of his history was not relevant. He had never had a roentgen examination of the chest. Later on, because of some unusual roentgen findings, on physical examination a right-sided paravertebral dullness was percussed. On auscultation of the heart region, no murmurs or bruit was heard; there was no thrill over the cardiac region.

On roentgenoscopic examination of the chest, preceding administration of barium, a large pulsating mass having a right convex border was seen, enlarging the heart shadow to the right side. The right hilum could not be seen. The right border of the mass originated about 1 inch above the right diaphragm, extended into one-third of the right lung field with the peak at its convex border. The density of the shadow could not be differentiated from the heart shadow and the finding was interpreted as due to aneurysm of the ascending aorta. The rate and time of the pulsations of the right mediastinal mass coincided with the rate and time of the radial pulse. The amplitude of the pulsations was moderate.

FIG. 1. Teleroentgenogram of chest. The cardiovascular shadow is enlarged on the right side by a pulsating mass constituting the right border of the cardiovascular shadow.

The trachea deviated to the left at the level of the aortic arch. With the intention of judging the width of the aortic arch, a barium mixture was administered and the esophagus was found to be to the right of the aortic knob. In the right anterior oblique position the aortic arch was posterior to the visualized esophagus, a finding sufficient for the diagnosis of right aortic arch. Nevertheless, the pulsating right mediastinal mass remained unexplained and the final diagnosis was made by the aid of roentgenograms.

On the posteroanterior teleroentgenogram the region of the pulsating shadow appeared less dense than the remainder of the cardiovascular shadow. It is almost axiomatic that normal and abnormal cardiovascular shadows cast a uniform dense shadow. Moreover, by a study of the left anterior oblique view, the ascending aorta was not found dilated; there was no aneurysm of the root of the aorta. On the basis of its different shadow density, the pulsating mass was thought to be posterior to the remaining cardiovascular shadow. Further, it was observed on the left anterior oblique view that the aortic shadow cast a hairpin-like image and did not cross over toward the spine shadow in a wide arch, as it is ordinarily seen at a 60 degree rotation of the patient. The shadow of the descending aorta was not found up along the spine shadow, but recoiled toward the heart shadow and joined the left border of the heart high up,

that is the aorta curved into the right lung field. The right anterior oblique view has shown that the aortic arch is located posterior to the esophagus.

DISCUSSION

The clinical significance of right aortic arch is small. It is recorded in the literature that it may cause dysphagia lusoria. In Golden's Diagnostic Roentgenology it is stated that dysphagia is not expected in this condition. In the case presented dysphagia was absent. Respiratory difficulty, due to pressure upon the trachea, is not noted to occur. However, this patient was said to have had shortness of breath since childhood. It was not likely that he had dyspnea in the circulatory sense and it is thought that pressure atrophy, even developmental deformity of the trachea, can be present, with a weak wall and a degree of partial collapse on increased respiratory effort. Normally the innominate and subclavian arteries develop from the fourth embryonal aortic arch on the right side. From the pair of this arch on the left side the normal aorta develops. Exceptionally the aorta develops from the right fourth arch, as in our case. It is interesting to note the relationship of the innominate artery to the trachea. It is suggested that as the precursor of the innominate artery develops into the anomalous right aorta, the trachea is not only crowded to the left side, but maldevelopment should be the result of such displacement from early embryonal life.

Fig. 2. Right anterior oblique view of chest, showing the presence of right aortic arch.

Fig. 3. Left anterior oblique view, indicating that the descending aorta is not found in its normal anatomical location, but its course is changed. The ascending and descending aorta forms a hairpin-like shadow at a 60 degree rotation of the patient.

From the viewpoint of roentgen diagnosis, elongated and tortuous right descending aorta is a rare occurrence. At routine film reading, the cardiovascular shadow will be found enlarged, the configuration suggests rounded mediastinal mass possibly aneurysm of the ascending aorta. It will be found that the shadow of the mediastinal mass has a lesser density, particularly on its periphery, than the heart shadow. In the region of the ascending aortic shadow, no clear differentiation can be seen. In the re-

gion of right auricle, the auricular border is partly seen for a short distance. On the left side, the cardiovascular angle is absent. The knob is not found in the left heart border. In the presence of a mediastinal mass, the appearance of the left heart border may be due to rotation of the heart as well as caused by a right aortic arch. The displacement of the trachea may occur with various mediastinal pathological conditions. Careful examination of the region of the displaced trachea would show that the bare shadow of the manubrium sterni is exposed on a large area. On a well centered film this, with the displaced trachea, should indicate that the left aorta is absent.

In all cases of suspected aneurysm of the ascending aorta, administration of barium is the routine procedure in order to judge the width of the aortic arch. Following this procedure it is likely that a right aortic arch will be found. This finding will indicate that the protrusion on the right side of the cardiovascular shadow is the elongated and tortuous right descending aorta. Correspondingly, on the roentgenogram taken in the left anterior oblique view, the hair-pin-like shadow formation of the ascending and descending aorta will be found. The descending aorta will not be found in its normal anatomical location along the spine shadow.

CONGENITAL HYDRONEPHROSIS CAUSED BY A POLAR ARTERY*

REPORT OF A CASE

By EDMUNDO INGBER, M.D.
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THE case history which follows has not been published before because we wanted to observe the postoperative results for a sufficient length of time. It has now been more than a year since the operation and the patient has resumed his work, using a bicycle as a means of transportation.

B.S., aged thirty, unmarried, native of Santa Fe, Argentina.

Family and past history, irrelevant.

History of Present Illness (Dr. Ricci). The patient came for examination because of sexual impotence which had not responded to various treatments. Urinalysis showed traces of pyuria.

A roentgenogram of the urinary tract taken without contrast medium showed in the left kidney five shadows of foreign bodies with small satellites (Fig. 1).

Ascending pyelography after the introduction of 10 cc. thorotrast (Dr. Ricci) showed notable dilatation of the ureter with an interruption at the lower pole of the left kidney, dilatation of the kidney pelvis and enlargement of the calices. In the contrast medium could be seen the foreign bodies which were noted in the previous examination, establishing the diagnosis of these shadows as renal calculi (Fig. 2 and 3).

Descending intravenous pyelography (perabrodil 10 cc., Dr. Lauria), with compression of the ureters. Right kidney: Good beginning elimination at seven minutes after the injection. "Camel's back" pelvis. Moderate dilatation of the calices. At the end of twenty minutes the kidney pelvis appeared markedly dilated, the calices a little larger than normal in the lower sector, markedly constricted in the upper sector. At the end of thirty-five minutes after the intravenous injection and without compression of the ureters the flow appeared slow, the pelvis remained dilated, in a position of median posterior rotation (Fig. 4 to 6). Left kidney: From the first moment of the examination the contrast medium collected in numerous pseudocystic cavities but without the production of a normal form of either the pelvis or the ureter. The renal calculi could be seen through the contrast medium (Fig. 4 to 7).

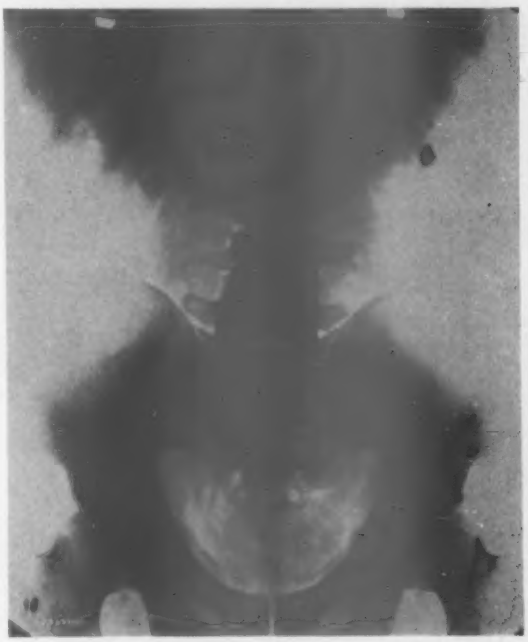

FIG. 1. Plain roentgenogram, without contrast medium.

Clinico-roentgenological Diagnosis: Congenital hydronephrosis resulting from a polar artery.

The therapeutic indication was left nephrectomy.

Surgical Operation (Dr. Ricci; Dr. Farias). The operation was Guyon's incision.

* Translation made by Dr. Audrey G. Morgan, Medford, Ore.

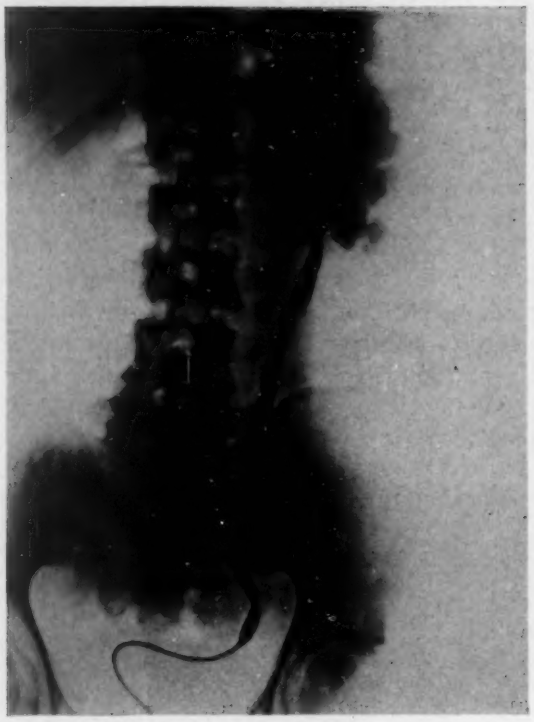

FIG. 2. Ascending instrumental pyelogram with the use of thorotrast. Left kidney.

FIG. 3. Showing detail of Figure 2.

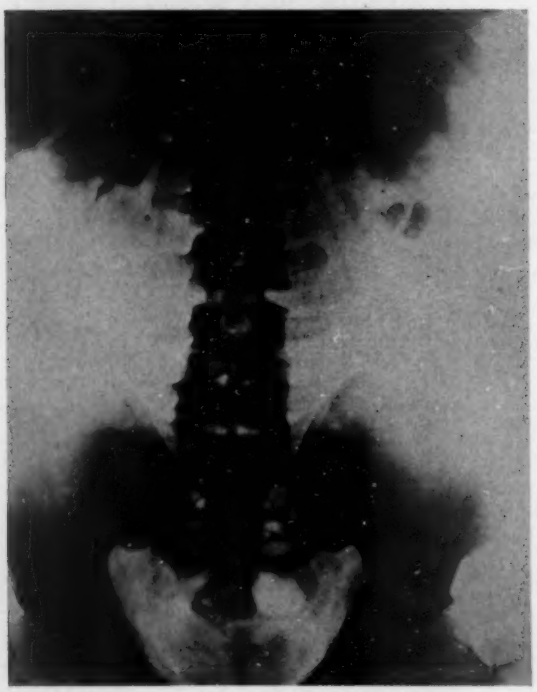

FIG. 4. Intravenous pyelogram with perabrodil. Seven minutes after injection with compression of the ureters.

FIG. 5. Same as Figure 4. Twenty minutes after injection and with compression of the ureters.

FIG. 6. Same as Figures 4 and 5. Thirty-five minutes after the injection and without compression of the ureters.

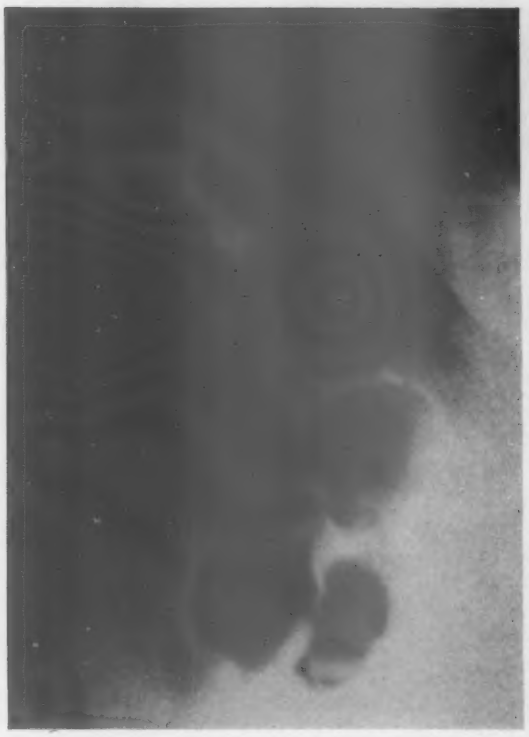

FIG. 7. Showing detail of Figure 6.

FIG. 8. Operative specimen. Left kidney. General view, external.

FIG. 9. Same as Figure 8. General view, median incision in the external border and the five calculi.

On opening the perirenal capsule the kidney was found to have only a small amount of parenchyma and a large pelvis. Nephrectomy was performed and the operative specimen removed.

Description of the Anatomical Specimen (Dr. Ricci). Kidney with lobulated external appearance, confirming the pseudocystic images which had been seen roentgenologically. On opening the kidney, dilatations were found in the pelvis and calices in the interior of which the stones seen on the roentgenograms were found. The picture of the operative specimen was amost identical with that shown by Marion in his textbook as classical (Fig. 8 to 10).

Anatomo-pathological Diagnosis: Congenital hydronephrosis from a polar artery.

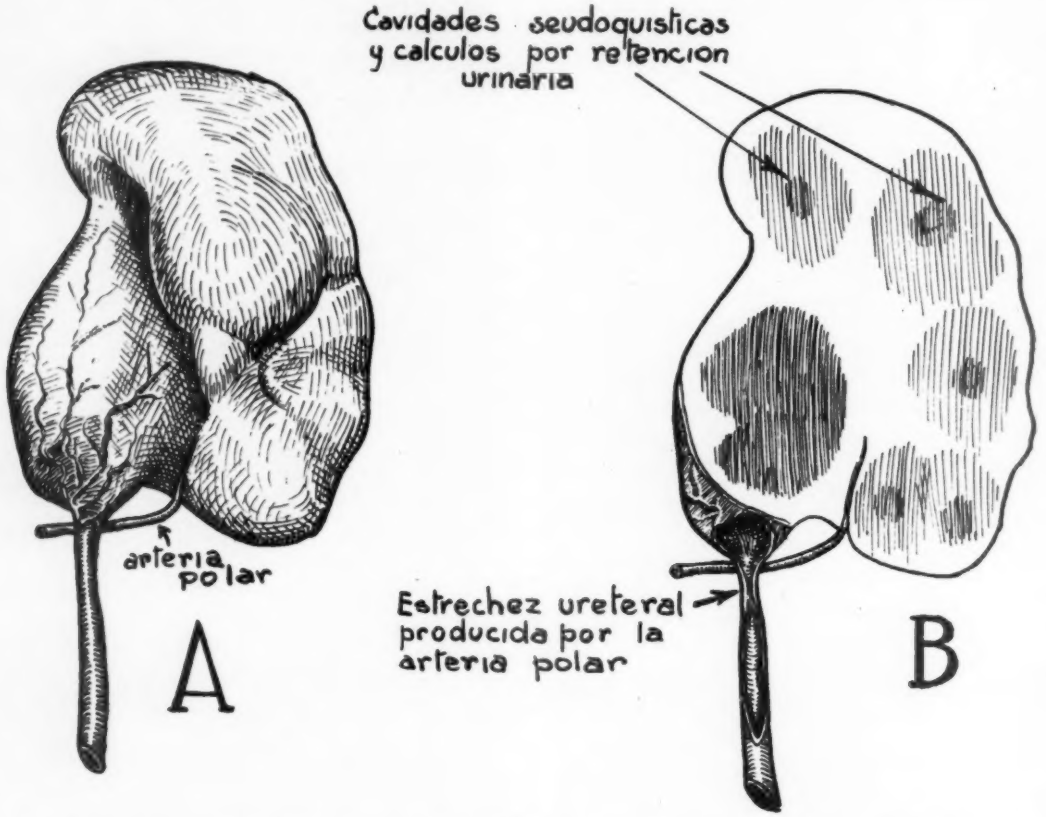

FIG. 10. Hydronephrosis from an abnormal vessel. (From Marion, G. Traité d'urologie. Masson et Cie, Paris, 1935, p. 468. Modified by the author with reference to the case presented.) *A*, Polar artery. *B*. Pseudocystic cavities and calculi from retention of urine. Constriction of ureter caused by polar artery.

The patient was discharged ten days after operation on the way to perfect reestablishment of health.

CONCLUSIONS

It seemed to us interesting to publish this report as an additional case of this condition and for the following reasons: (*a*) scarcity of clinical symptoms for establishing a diagnosis; (*b*) pathognomic value of the roentgen data; (*c*) perfect clinical-surgical cure.

Vol. 53, No. 3

ABERRANT PANCREATIC TISSUE AS A ROENTGENOLOGIC PROBLEM*

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ANATOMISTS and pathologists have long been conversant with variations in the placement of pancreatic tissue, but in scanning the roentgenological literature there is little specific reference to this problem. It is true that a number of writers make passing references to aberrant nodules of pancreas. Sahler and Hampton[4] describe the smooth defects occasionally produced in the stomach by aberrant pancreatic tissue and Strnad,[5] in his very comprehensive treatise on the duodenum, discusses the warty pancreatic growths frequently encountered in the duodenal mucosa.

Our attention was focused on this problem because of the experience gained recently in the study of a number of puzzling cases in which the roentgen diagnoses were accepted without reservation, proving incorrect in one instance and correct in another. Interestingly enough, the opinion that proved to be wrong was made with extreme assurance and pride, whereas the diagnosis that was correct was offered only after studied deliberation.

The close embryological relationship of the duodenum and pancreas, with the latter originating as buds from the former, makes it easy to understand why there are small clumps of pancreatic tissue frequently imbedded in the duodenum and other portions of the intestinal tract. It has long been recognized that duodenal diverticula may actually occur at sites where pancreatic arrests produce potential weak spots in the intestinal wall. When a diverticulum exists, no confusion ensues, for the pouch is ordinarily easily demonstrated.

What if the aberrant pancreatic nodule does not lead to an eventual outpouching, but, as in one case recently studied, produces a persistent filling defect in the duodenal mucosal pattern? Figure 1 shows such a defect in the descending loop of the duodenum. This was brought out well by the use of a pressure block and spot roentgenograms, but was suspected on the routine roentgenograms. Because the patient was jaundiced, and because his entire clinical course pointed to a diagnosis of cancer of the head of the pancreas, we very confidently interpreted the defect as evidence of a lesion of the ampulla of Vater. This diagnosis was readily accepted for it certainly was a satisfactory explanation of the patient's signs and symptoms. Moreover, intensive clinical studies were in no way at variance with the roentgenological interpretation.

After a period of adequate preoperative preparation, the patient was explored. When the peritoneal cavity was entered the surgeon noted immediately that the gallbladder was normal in size and that it emptied readily on slight manual pressure. Also, the head of the pancreas was normal. Palpation of the duodenum elicited a nodule on the posterior wall; therefore this structure was opened. The nodule was located just above the papilla and it was evident that it could in no way have been a causative factor in the production of the jaundice. A biopsy study revealed that the so-called roentgen ampullary defect was due actually to a cluster of aberrant pancreatic tissue.

The patient subsequently died and complete necropsy studies proved clearly that death was a result of an extensive inflammatory process of the liver. The changes in the liver were diffuse and had caused edema and necrosis of the biliary canaliculi, which of course accounted for the obstructive

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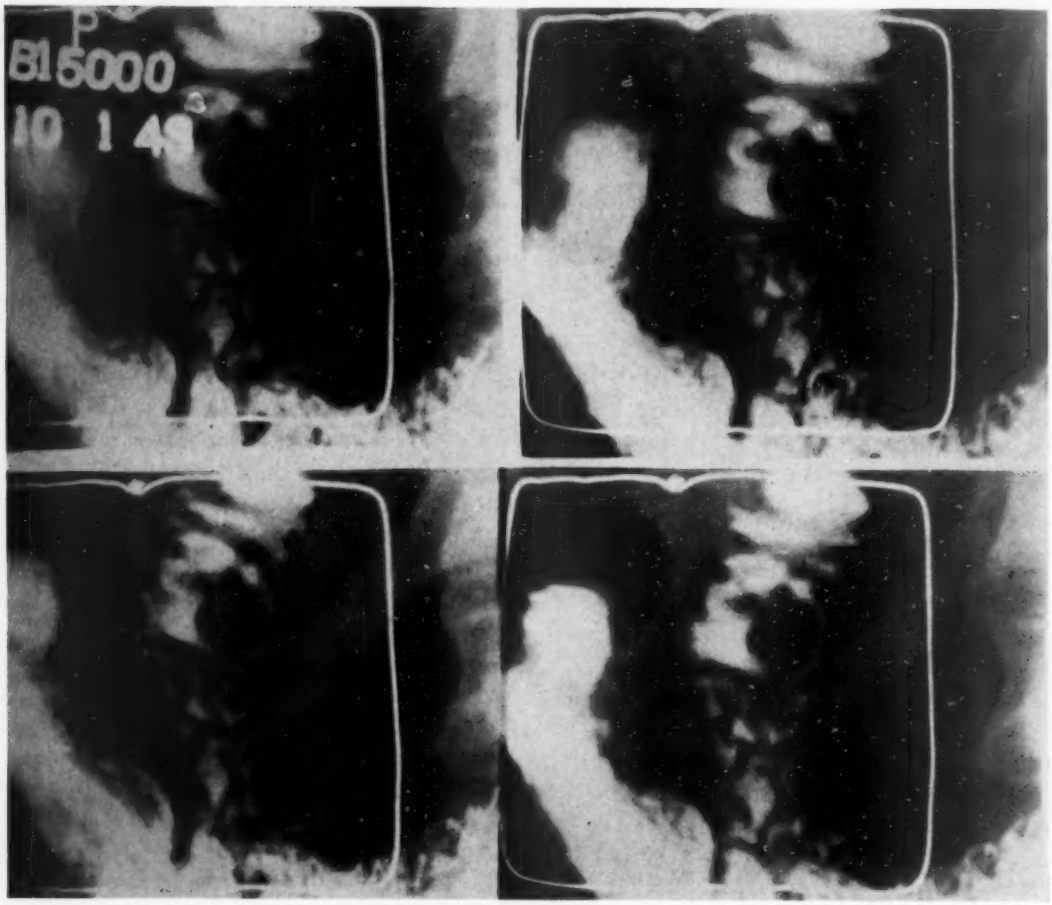

Fig. 1. Serial roentgenograms showing the defect in the duodenum that was incorrectly interpreted as cancer of the ampulla of Vater. A cluster of pancreatic tissue produced the constant change seen.

jaundice. It is interesting to note that in spite of the marked changes found in the liver, the various clinical tests pertaining to liver function failed to yield the information that would have aided materially in arriving at a correct diagnosis.

A number of instances have been recorded in which a defect of the ampulla of Vater was demonstrated roentgenographically and undoubtedly a cancer of this structure can and will at times produce certain roentgen pattern changes. Obviously, however, we are convinced that the problem of a correct diagnosis is not so simple as the mere finding of a filling defect in the vicinity of the ampulla. Feldman[1] has stated that by careful mucosal studies the normal ampulla can be identified, but certainly it is not a roentgen appearance that can be consistently duplicated. Had we been able to localize the normal papilla, we naturally would not have been so positive in our interpretation of the defect demonstrated.

The more carefully the roentgenologist studies the gastrointestinal tract, the more frequently will such defects as described be encountered. When discovered in the absence of jaundice or symptoms they may present no particular problem. But, whenever they are detected in patients with jaundice or vague digestive symptoms it becomes extremely important for the roentgenologist to interpret the roentgenograms with a critical and cautious attitude.

Another aspect of aberrant pancreatic tissue which merits discussion is the pres-

ence of an encircling ring of pancreas about the duodenal loop. Lehman[3] reported what is perhaps the first case diagnosed prior to operation and in his article he reproduces photographs showing a smooth narrowing of the second portion of the duodenum. It was on the basis of this type of narrowing that Lehman was led to suspect the true underlying condition. Gross and Chisholm[2] in a recent article discuss the annular pancreas from the standpoint of diagnosis and treatment.

Recently we made the diagnosis of obstruction of the duodenum secondary to acute pancreatitis with possible annular constriction. Figures 2 and 3 show the duodenum prior to operation and some weeks after operation. The patient had been explored on several previous occasions prior to the present illness, and a few weeks before admission she began to complain of intermittent cramps, subsequently developing a constant epigastric pain associated with bouts of vomiting. Clinically, it was

FIG. 2. Obstruction of the second portion of the duodenum is clearly demonstrated. Note also the changes in the upper jejunum which are secondary to a pancreatitis.

FIG. 3. Roentgenogram after operation demonstrating the smooth narrowing of the duodenum when the inflammatory process had subsided.

felt that postoperative adhesions accounted for the symptoms. After proper clinical studies the patient was referred to the roentgenological department for consultation. The duodenal obstruction was demonstrated, which, coupled with the presence of an effusion at the left base and definite alterations in the small bowel pattern and physiology, led to a roentgen diagnosis of pancreatitis, plus probable circular constriction of the duodenum by aberrant or ectopic inflammatory pancreatic tissue. The operative findings coincided completely with the roentgen diagnosis.

The pancreas that encircles the duodenum completely or partially is not rare and the diagnosis must be considered seriously in every instance of a persistent narrowing in the size of the duodenal lumen at its second portion. Frequently, there may be no symptoms when the condition is present, but more often in the face of vague symptoms the true diagnosis is apt to be overlooked. Unless the roentgenologist acquaints himself with the possible variations

and aberrations in the duodenal pancreatic relationships he will undoubtedly be lured into error when he least expects it.

In this discussion of aberrant and ectopic pancreatic tissue and its roentgen manifestations, only a few of the manifold aspects have been touched upon. However, it is hoped that our experiences will serve in some measure to direct attention to this interesting aspect of abdominal roentgen studies, and that others will record their findings so that eventually a more complete understanding and appreciation of the subject may be attained.

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NECROTIZING BRONCHOPNEUMONIA*

ITS RELATION TO RADIATION THERAPY OF CANCER OF THE ORAL CAVITY

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NECROTIZING bronchopneumonia and necrotizing suppurative bronchopneumonia[1] are more descriptive and accurate terms for aspiration pneumonia. Necrosis of the bronchial walls and suppuration of lung parenchyma supplied by the involved bronchus or bronchi are invariably present. The distribution is lobular and localized to one or more bronchopulmonary segments. Patients with cancer of the oral cavity have an excellent chance of developing this complication, particularly if the lesion interferes with deglutition. The presence of bacteria in the mouth, poor oral hygiene, advanced pyorrhea and root snags are also contributing factors. Pain on swallowing resulting in deficient nutrition, avitaminosis and lowered serum proteins all are conducive to the onset of pneumonia. If to these factors poorly planned radiotherapy is added, the chances of the patient aspirating broken-down tumor and bacteria becomes great.

Of the 14 cases we have observed, 3 had primary carcinoma of the tongue, 2 of the lip, 3 of the buccal mucosa, 5 of the larynx and 1 of the gum. Twelve of these patients died after completion of treatment, the shortest time interval before death being three days and the longest period eleven months. The 2 remaining patients, whose clinical symptoms and roentgen findings strongly suggest necrotizing bronchopneumonia, are well.

The clinical signs and symptoms of necrotizing bronchopneumonia are uniform and once seen are easily recognized. If a patient with cancer of the oral cavity begins to lose weight rather quickly and develops a rapid pulse with a low grade fever, necrotizing pneumonia should be considered. There is often coughing, but little or no dyspnea or sputum. The breath is not foul as in lung abscess nor is clubbing of the nails present. Evidence of patchy consolidation is present on physical examination.

The diagnosis of necrotizing pneumonia by the roentgen ray may present difficulties. There are always changes present in the lower lobes and if the process is extensive enough it may also involve the upper lobes. The process being a bronchopneumonia, the changes will be lobular in character and of bronchial distribution. The areas of involvement will at first have a patchy to confluent cloudiness but as the disease progresses and liquefaction of the centers occurs, areas of rarefaction will make their appearance and the diagnosis will be more obvious. However, as the process continues, other areas may become involved so that the areas of rarefaction may be present in some zones and absent in others. Tuberculosis can be ruled out as the process is primarily basal and often extensive without apical involvement. Chronic passive congestion can be ruled out because of absence of engorgement of the vascular tree and enlargement of the heart. Atypical primary bronchopneumonia may be suggested but this disease usually appears in epidemic form and the clinical course is entirely different. Organization of the exudate with production of connective tissue surrounding the abscess produces zones of increased density. These areas may be circular, often with central rarefaction, and may suggest metastatic disease, although tumor originating from the lip, tongue, and larynx metastasize infrequently to the

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[1] Neuhof, H. Suppurative and necrosuppurative bronchopneumonia; their surgical aspects. *Dis. of Chest*, 1940, 6. 299–305.

lungs. Because of the patchy distribution and the fluffy appearance of the lesion, specific infections of fungus etiology may be considered. Examination of sputum should serve to rule out such infections as well as tuberculosis.

The pathology of necrotizing pneumonia is quite uniform, the changes varying only according to the duration and extent of the disease. The lungs are heavy and in our 12 autopsied cases had an average weight of 800 grams. The pleura over the involved lobes showed a fibrinous exudate, but in no instance had perforation and empyema occurred, a complication which would not have been unexpected. In every instance one or both lower lobes were involved: all lobes in 3 cases, four lobes in 3 cases, three lobes in 3 cases, two lobes in 2 cases and one lobe in 1 case. The bronchi were diffusely injected and in many instances contained thick, purulent material. In no instance was the disease of sufficiently long duration to produce bronchiectasis. The exudate was so heavy that the bronchi were often plugged. The pulmonary vessels were practically normal. Section of the lungs showed the involved lobes to be very heavy, the pneumonia patchy and bronchial in distribution. These pneumonic areas at times became confluent. Pressure of the involved lobes often produced pus from the small bronchi. Sometimes central softening of the involved areas had taken place and surrounding these areas of softening were firm yellowish zones which occasionally were well demarcated. Because of this sharp demarcation, an area of pneumonia located just beneath the pleura was thought on one occasion to be a metastatic focus. Various stages of the same process were often seen in different lobes, the earlier lesions having marked congestion and edema. The lungs had an offensive, but not a foul odor. Where the areas of necrosis had progressed at a rather rapid rate, small abscesses frequently formed which varied in size from a few millimeters up to 4 centimeters. Five cases had abscesses, but unfortunately it was impossible to determine definitely the duration of the pneumonia. Undoubtedly the evolution of the abscesses in many instances was very rapid because necrosis of bronchial walls is favored particularly by the anaerobes present.

The microscopic changes were also consistent. Foreign material, large clumps of bacteria, and polymorphonuclear leukocytes were often observed within the lumina of the bronchi. Partial or complete necrosis of the lining epithelium of the bronchi, which was usually present, resulted in some instances in the disappearance of the bronchial mucosa (Fig. 6). Where the process had progressed to abscess formation, lung parenchyma was completely absent. The wall of the abscess was lined with bacteria, fibrin and collections of polymorphonuclear leukocytes. Early organization commonly surrounded the abscess, this organization giving grossly a yellow color. In earlier lesions, marked congestion and edema were present.

The bacteriology was varied. Spirochetes, fusiform bacilli, anaerobic hemolytic streptococci, staphylococci, *Streptococcus viridans*, and various other organisms commonly seen within the oral cavity were usually found. Cultures always showed a mixed flora. Anaerobes were always present

We believe that the primary cause of necrotizing pneumonia as associated with cancer of the oral cavity may be related to poorly planned radiotherapy. Scrupulous mouth hygiene and the extraction of all teeth is indicated before starting roentgen therapy. The size of the fields should be as small as possible, giving careful attention to the size of the lesion and to the filtration, with protraction of irradiation over a rather long period of time. If large fields are used in excessive doses with little or no filtration, extreme irradiation reaction with radionecrosis, edema, fibrosis and distortion of the swallowing structures may result.

After necrotizing pneumonia has developed, the chances of cure are very small unless early treatment is instituted. Since pneumococci are not the cause of necrotiz-

ing pneumonia, specific serum therapy is of no value. Sulfadiazine may affect some of the organisms but the anaerobes are not sensitive to it. Surgery was not indicated in any of the cases because extensive parenchymal disease was present with the abscesses. Roentgen therapy is probably the only specific agent which may be of value. A fairly large field should be selected and small doses given for three or four days. Two of the patients reported in this paper recovered from an apparently early necrotizing pneumonia, for which small doses of roentgen radiation were given.

The following cases illustrate the more significant findings in our studies of necrotizing pneumonia:

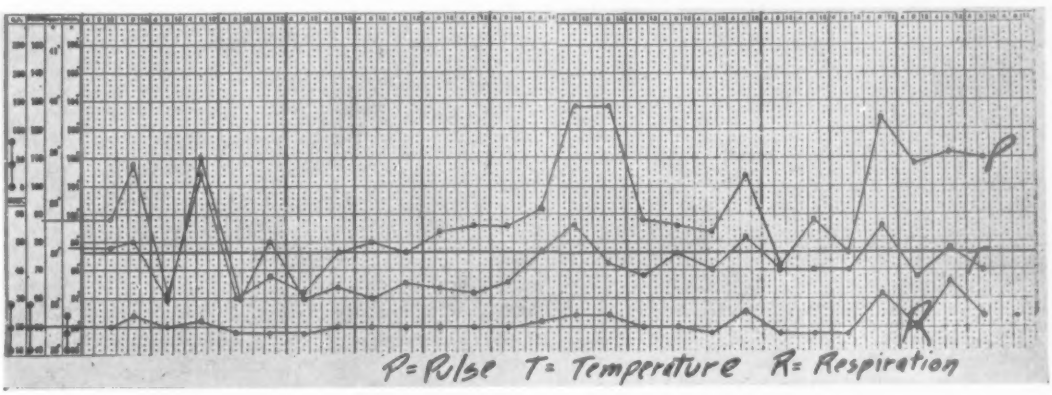

FIG. 1. Case 1. Note high pulse rate with relatively low temperature.

CASE REPORTS

CASE 1 (EFSCH 4239). R. D., male, aged fifty-six, was admitted to the hospital on July 17, 1942. In May, 1941, the tongue first became sore and the following October, at another hospital he was given 4,800 r to the submental region, and over two lateral 8 by 10 cm. fields. The lesion of the tongue was treated with 3,510 mg-hr. of radium introduced interstitially. This treatment was given over a fifteen day period, during which time the patient lost 40 pounds. In April, 1942, a hard mass appeared below the angle of the right mandible, evidently a metastatic node. Physical examination showed a chronically ill male with marked evidence of weight loss. The teeth were absent and the mucosa of the oral cavity was dry and smooth. Râles were present at the base of the right lung and in the axilla. Examination of the sputum revealed no tubercle bacilli but did show a mixed flora including anaerobes. The patient was running a low grade fever and had a high pulse rate (Fig. 1). Roentgenograms were taken on July 20 and 27, 1942 (Fig. 2, *A* and *B*), and the patient died on July 30, 1942.

This process was probably inflammatory but tuberculosis was considered. However, there was no involvement of the apices and sputum examination for acid-fast organisms was negative. At autopsy the tongue was atrophic, the epiglottis was distorted and the lungs showed an advanced necrotizing pneumonia. The lungs together weighed 1,580 grams and pneumonia was present in all but the superior portions of both upper lobes. There were several small abscesses measuring no more than 2 cm. in the right lower and middle lobes. Surrounding these abscesses were yellowish zones suggesting early organization. No abscesses were present in the left lung.

The immediate cause of death was an advanced necrotizing bronchopneumonia with the formation of multiple abscesses. The patient died eleven months after the completion of roentgen therapy for carcinoma of the oral cavity. The poor nutrition and extensive radiation effect in the region of the base of the tongue and larynx, which caused marked fibrosis and distortion of the structures involved in deglutition, resulted in the aspiration of food particles and necrotic debris. There was no evidence of residual carcinoma in the tongue, but it was present in the cervical lymph nodes.

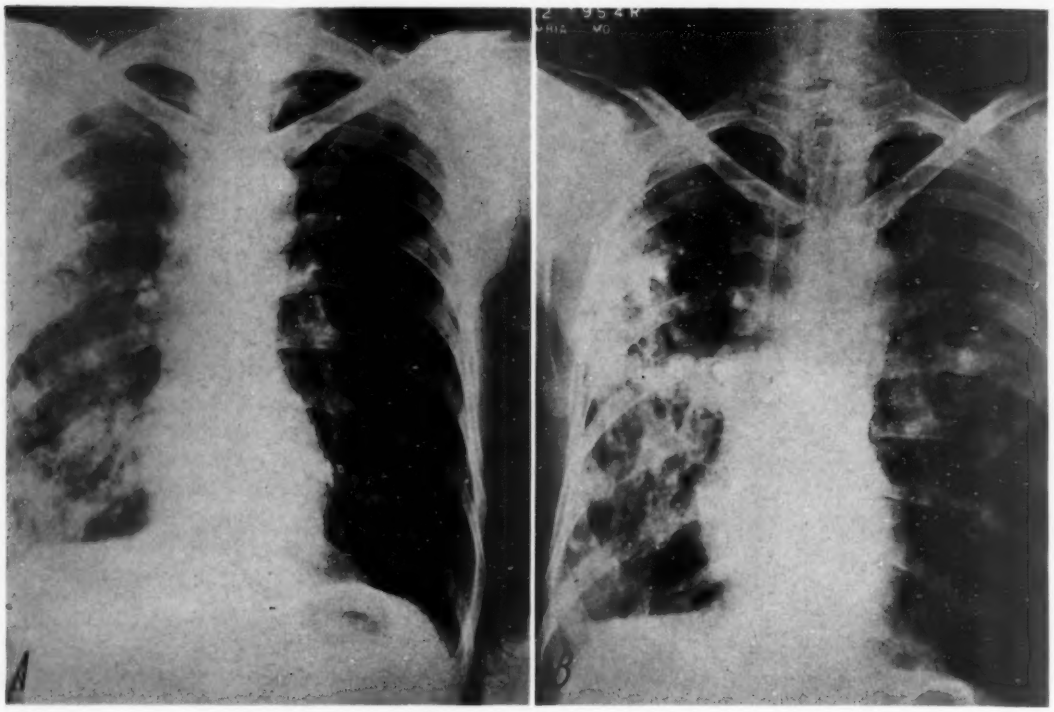

FIG. 2. Case 1. *A*, July 20, 1942. Note soft patchy to confluent cloudiness extending from the anterior end of the right second rib to the diaphragm together with small areas of increased translucency. There is also evidence of early disease in the dependent two-thirds of the left side of the chest. *B*, July 27, 1942. The lesions on the right have become more confluent and the areas of increased translucency more evident. Similar disease on the left is minimal.

CASE II (EFSCH 4165). C. J., female, aged thirty-nine, was admitted to the hospital on July 1, 1942. Two years before, a small lesion was noted directly beneath the tip of the tongue. This lesion increased in size rather rapidly and spread posteriorly to involve almost the entire left side of the tongue. The patient had lost about 15 pounds in weight. Physical examination showed a chronically ill woman, with evidence of poor general nutrition. The teeth were in fairly good condition, but the entire lateral surface of the tongue was involved

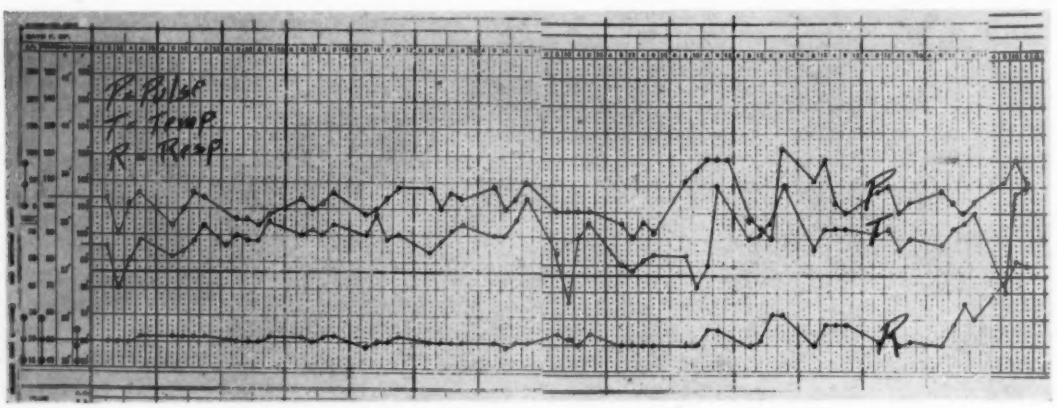

FIG. 3. Case II. Note high pulse rate with relatively low temperature.

by hard firm tumor which extended posteriorly to the tonsil. There was a firm lymph node measuring 3 cm. in diameter in the left submaxillary area. The patient was given 7,500 r in thirty days, using 200 kv., 15 ma., 50 cm. target-skin distance, with a filtration of 0.5 mm. copper and 1 mm. of aluminum. These fields were lateral, submental, and measured 6 by 8 cm. During the entire stay in the hospital the patient ran a low grade fever with a relatively high pulse rate (Fig. 3). She lost about 20 pounds during therapy and weighed only 80 pounds when she died on July 13, 1942. A roentgenogram taken on June 2, 1942, was essentially negative. Another was taken on July 13, 1942 (Fig. 4), the day of her death.

At autopsy extensive necrotizing pneumonia was found to involve the entire left lung and the right lower lobe in which were multiple small abscesses. The bronchi contained large amounts of mucopurulent material. The larynx showed marked distortion of the epiglottis with edema and marked swelling of the glossopharyngeal

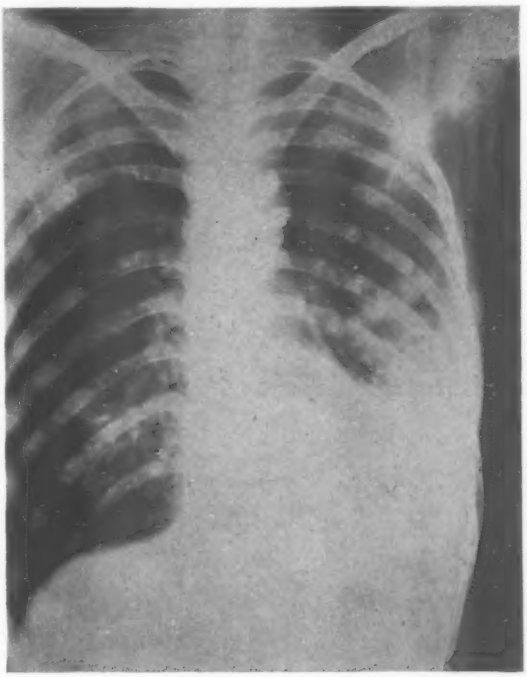

Fig. 4. Case II. There is minimal patchy cloudiness in association with the descending paravertebral trunk markings on the right. This change is most evident underlying the anterior end of the right fourth rib. The disease is considerably more marked on the left, increasing progressively downward resulting in complete opacity in the left base.

Fig. 5. Case II. Note distortion of the epiglottis with marked edema of the glossopharyngeal wall.

wall (Fig. 5). Microscopically, there was necrosis of the bronchial wall (Fig. 6) with multiple small areas showing central necrosis in large colonies of blue-staining bacteria. There was peripheral early organization of the exudate.

This patient received a large amount of roentgen therapy through large fields over a short period of time. This provoked a marked radio-epithelitis resulting in distortion of the epiglottis with fibrosis of the base of the tongue and marked edema of the glossopharyngeal wall. It is obvious that aspiration of foreign material and oral bacteria would be facilitated by these changes. Death occurred on the third day after completion of radiotherapy.

Case III (EFSCH 4635). E. B., male, aged sixty-nine, entered the hospital October 12, 1942. The previous July, hoarseness first developed and was treated as chronic bronchitis. After a delay of several months, a diagnosis of carcinoma of the larynx was made. Physical examination revealed a fairly well developed male who presented bilateral enlarged cervical lymph nodes. In the region of the right piriform sinus

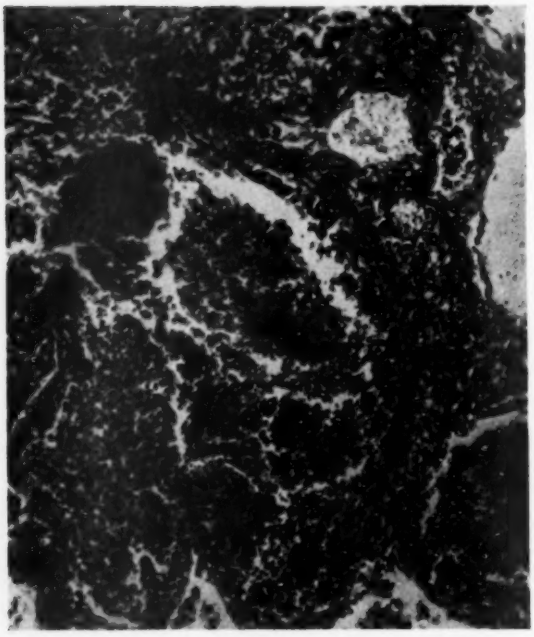

FIG. 6. Case II. Photomicrograph (low power). Note necrosis of the wall of the bronchus (*B*). The bronchial lumen is filled with polymorphonuclear leukocytes and amorphous debris.

there was an elevated, reddish, crater-like lesion which was centrally necrotic and measured 1.5 cm. in diameter. Between October 19 and November 24, the patient received 6,500 r to two fields, one 10 by 15 cm. and one 8 by 10 cm., using 200 kv., 15 ma., 50 cm. target-skin distance, 1 mm. of copper and of aluminum. This treatment extended over a period of thirty-five days, during which time in spite of slight weight loss the condition remained good. By February 24, 1943, the left neck node, which previously measured 3 by 4 cm., had completely disappeared. There was, however, an additional node in the right cervical region measuring 2 cm. into which radium was implanted on March 10, and a total of 1,000 mg-hr. given. On June 9, there had been a weight loss of 17 pounds and the patient had been spitting up thick yellow sputum for several weeks. Laryngoscopic examination showed edema of the epiglottis which was fixed more or less in the open position. The vocal cords were spread apart and there was edema of the left cord with flattening of the right cord. A zone of ulceration measuring 2 by 1 cm. was observed in the region of the right piriform fossa. A roentgenogram of the chest was taken on June 15, one day previous to his death (Fig. 8).

At autopsy there was a zone of necrosis in the piriform sinus extending to involve the right lateral wall of the pharynx (Fig. 9). The right arytenoid was almost entirely destroyed and the ala of the thyroid cartilage was exposed and necrotic. The endolarynx was not invaded by this necrosis. False and true cords were edematous and the epiglottis was distorted. Necrotizing pneumonia involved the entire left lung and the right lower lobe. The process in the right lower lobe was somewhat older than the left because organization of the exudate was present. Residual disease was found in the mesenteric, peripancreatic, cervical and aortic lymph nodes and in the liver.

The immediate cause of death was an extensive necrotizing bronchial pneumonia. The primary cause was necrosis in the region of the piriform sinus, which together with the changes in the larynx secondary to irradiation, paved the way for aspiration of necrotic debris. In giving roentgen treatment to lesions in this location, the margin of safety between adequate therapy and irradiation necrosis is dangerously limited. When irradiation necrosis occurs, necrotizing pneumonia almost inevitably follows.

CASE IV (EFSCH 5178). G. J. This patient, a man aged seventy, was admitted to the hospi-

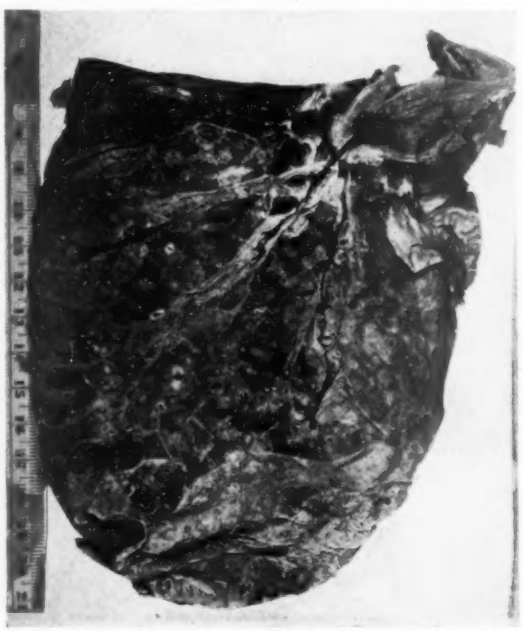

FIG. 7. Case II. Note multiple small abscesses.

tal on April 26, 1943. Three months previous to admission he noted increased hoarseness and he was referred to this hospital. Physical examination revealed a well developed, well nourished male. The mouth was edentulous. In the right piriform sinus there were areas of slough surrounded by an ulceration which involved the piriform and the epiglottic fold from the epiglottis down to and including the arytenoid. There were no enlarged cervical lymph nodes. Biopsy showed well differentiated epidermoid carcinoma, probably arising on the arytenoid epiglottic fold.

The right and left anterior cervical areas were given 3,800 and 2,675 r, respectively, through two fields which measured 6×8 cm. and the following factors were used: 200 kv., 15 ma., 50 cm. target-skin distance; filtration 1 mm. of copper and 2 mm. of aluminum. Radiation therapy was given twice a day for thirty-three days, starting with 100 r and gradually increasing to 150 r. A rather marked radio-epithelitis of the larynx developed and the patient lost 12 pounds in weight, but there were never any symptoms or signs of necrotizing pneumonia. On January 12, 1944, approximately eight months after completion of therapy, there was evidence of weight loss, dyspnea and increased

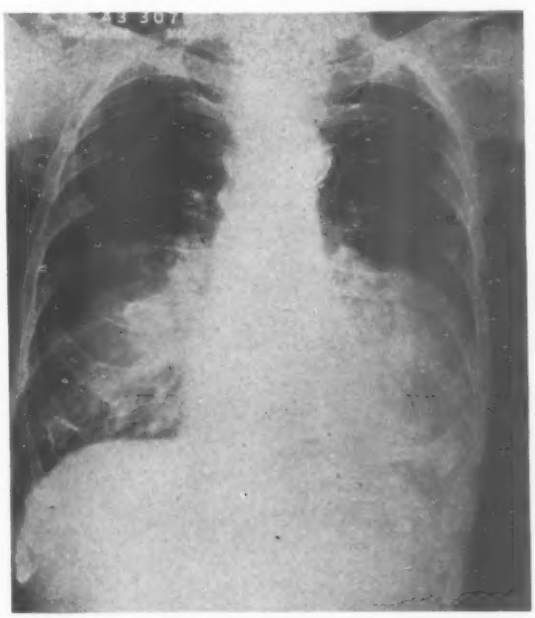

Fig. 8. Case III. Minimal patchy and considerable confluent cloudiness is present in both lung fields, extending from the hilar regions to the bases, more marked on the left.

Fig. 9. Case III. Note distortion of the epiglottis with necrosis and ulceration involving cartilage and pharyngeal wall.

fatigability. Examination revealed changes in the epiglottis with edema of the right arytenoid epiglottic fold and the anterior wall of the piriform sinus. A roentgenogram of the chest showed necrotizing pneumonia (Fig. 10*A*). He was given roentgen therapy using 218 kv., 1 mm. of copper and 1 mm. of aluminum; a 28 by 20 cm. field directed to the right side of the chest; 80 cm. target-skin distance, 100 r per treatment with a total dosage of 500 r. Symptomatically there was improvement with increase of weight. A roentgenogram taken on February 4, 1944 showed partial regression of the process. The last roentgenogram, May 10, 1944 (Fig. 10*B*), demonstrated complete clearing of the base, but linear bands of fibrosis were still observed in the second and third right interspaces. This suggests that healing of necrotizing pneumonia takes place at times by fibrosis, rather than resolution.

The second case which recovered from necrotizing pneumonia after roentgen therapy cleared by resolution. The treatment was given

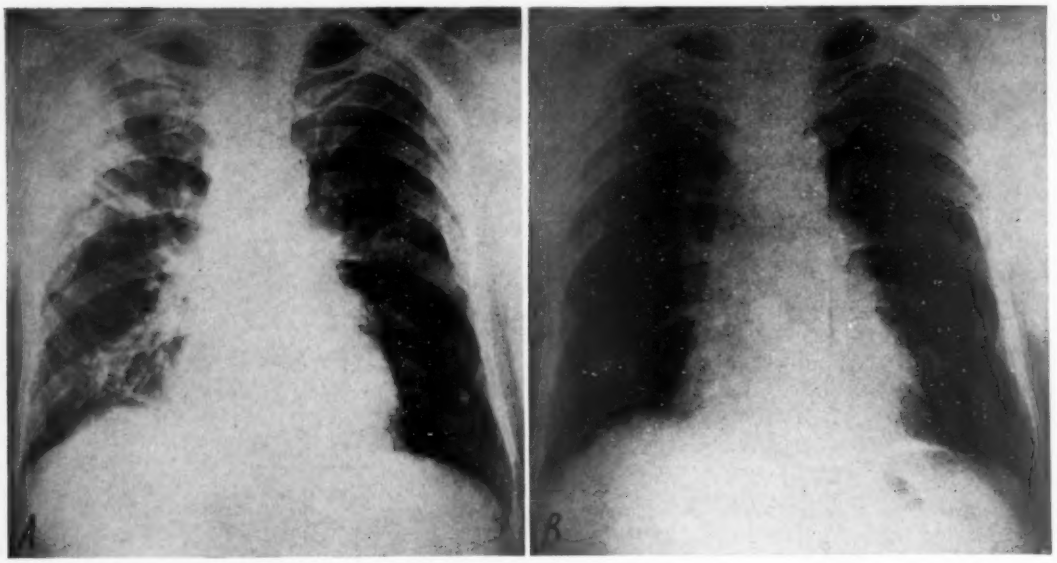

FIG. 10. Case IV. *A*, January 13, 1944. Linear markings on the right are exaggerated but poorly defined. Coarse dense to patchy cloudiness is present throughout a large portion of the lung, especially marked in the first and second anterior interspace and superior to the diaphragm. Minimal disease is suggested underlying the anterior end of the left rib. *B*, May 10, 1944. Final roentgenogram reveals regression of the parenchymal changes with considerable fibrosis most evident in the right upper part of the chest.

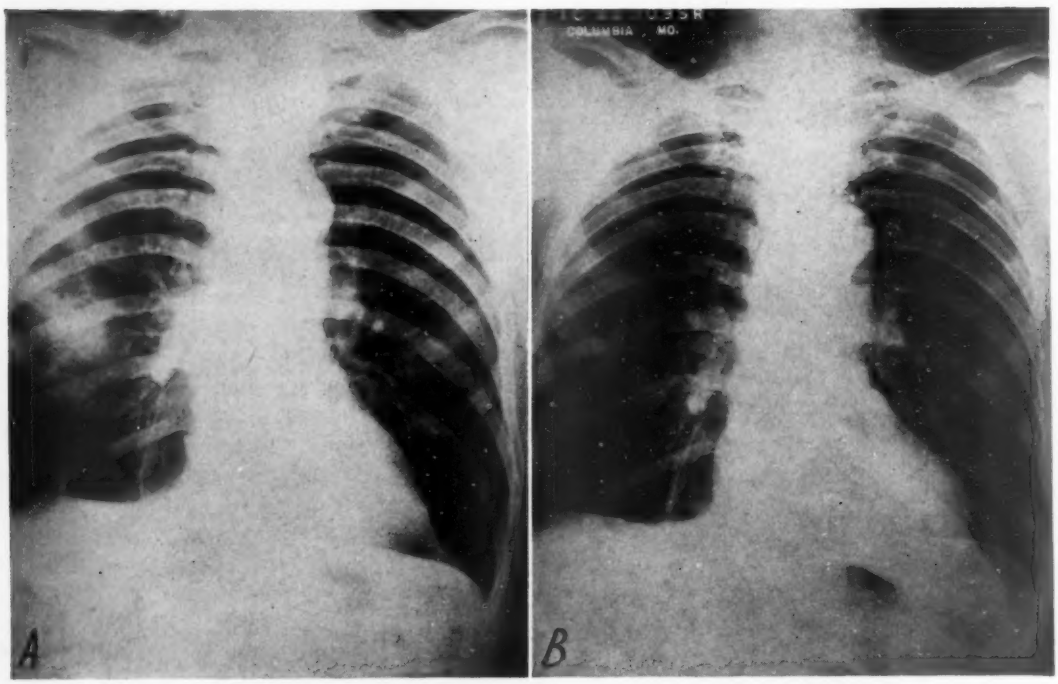

FIG. 11. *A*, September 7, 1943. Note area of irregular cloudiness in the right fourth and fifth anterior interspaces with a zone of indefinite translucency underlying the anterior end of the fifth rib. *B*, May 10, 1944. Final roentgenogram reveals complete resolution of the process.

in August, 1943. Resolution was nearly complete in January, 1944, and complete in May, 1944; a period of almost nine months (Fig. 11, *A* and *B*).

In both these cases, the diagnosis was made relatively early and a complete cure resulted from roentgen therapy. The diagnosis in both must be presumptive, but the clinical course and roentgen findings were typical of necrotizing bronchopneumonia.

DISCUSSION

Fourteen cases of necrotizing pneumonia, in 2 of which recovery took place, have been reported. This complication can occur during, immediately after, or relatively late after radiotherapy to cancer of the oral cavity and larynx. The clinical symptoms and signs are typical and a high pulse rate with a relatively low grade fever are of particular significance. The relation of the advanced pathology found by roentgen examination or at autopsy, in contrast to the rather meager clinical symptoms, often comes as a surprise to the observer. The roentgenographic pattern on serial roentgenograms is characteristic and the differential diagnosis is not difficult, providing adequate knowledge of the historical and clinical aspects of the case is available. The differential diagnosis and the characteristic features of the roentgen findings have been discussed. The most important preventive measure is carefully planned roentgen therapy with particular attention to divided dose technique, selection of fields and adequate filtration. The distortion, fixation, fibrosis, edema and ulceration produced by large fields, little or no filtration and large dosage given over a short period of time, lead inevitably to this complication and to death. If the complication is diagnosed late in the course of necrotizing bronchopneumonia there is no treatment which will be of any value. Roentgen therapy according to the technique outlined may be curative, if the lesion is diagnosed at an early stage.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Twenty-eighth Annual Meeting: to be announced.

EDITORIAL

THE QUESTION OF URETERAL OBSTRUCTION BY IRRADIATION

IN 1926, Herger and Schreiner[1] were greatly impressed by the fact that in 32 autopsies of patients dying from cancer of the cervix, 66 per cent showed gross pathologic changes of the urinary apparatus. As a result of this observation, a systematic study by means of cystoscopy and retrograde pyelography was undertaken on a series of 50 cases of carcinoma of the cervix of clinical Stage III and IV before any treatment was instituted. In 50 per cent a unilateral and sometimes a bilateral obstruction of the lower ureters was found associated with secondary hydronephrosis and pyonephrosis. The authors concluded that metastases and carcinomatous infiltration of the broad ligaments or bladder wall undoubtedly accounted for the obstructive process. In one case arriving at autopsy later, it was noted that radiation therapy administered subsequently resulted in complete eradication of the carcinoma, yet the patient died from complications of the upper urinary tract which apparently could not be influenced.

Since then, stress has been laid repeatedly on the important rôle which the frequent involvement of the upper urinary apparatus has in the outcome of all malignant neoplasms located within the pelvis. In the beginning, the expanding tumor exercises a slight pressure on the base of the bladder displacing the lower ureteral orifices or encroaches directly upon the lumen of the ureter itself. In either case, the resulting narrowing leads to a slowing down of the flow of the urine. During this period the patients have no symptoms and therefore an involvement of the urinary tract is discovered only accidentally or through systematic checkup examinations. Later, as the disease advances, the surrounding structures become invaded either by diffuse infiltration of malignant cells or by a superimposed cellulitis, and a progressive obstruction with hydroureter and hydronephrosis, sometimes associated with pyoureter and pyonephrosis, develops. It is almost universally true that 65 to 70 per cent of the patients afflicted with carcinoma of the cervix do not seek medical aid until the disease has reached clinical Stage III or IV, and therefore it is understandable that urinary complications should be encountered most frequently in connection with this type of lesion. But they also occur quite commonly in tumors of the bladder and prostate, in ovarian tumors and in other pelvic neoplasms. Seaman and Binnig[2] found that not even the caudalward located carcinomas of the rectum can escape them. These authors have performed routine investigations by means of intravenous pyelography and cystoscopy in a series of 68 cases of carcinoma of the rectum. They noted that in 13.2 per cent a simple or infected unilateral hydronephrosis was present at the time of the initial examination and that in another 13.2 per cent a similar condition developed at shorter or longer intervals after the operation. No radiation therapy was given in any of these cases.

During the last few years an increasing number of articles has appeared in the literature attributing the ureteral obstruction with the consequent hydronephrosis to

[1] Herger, C. C., and Schreiner, B. F. Strictured ureters, hydronephrosis and pyonephrosis occurring in cancer of cervix uteri; based on study of 82 cases. *Surg., Gynec. & Obst.*, 1926, *43*, 740–743.

[2] Seaman, J. A., and Binnig, C. Urological complications of cancer of rectum. *J. Urol.*, 1941, *46*, 777–797.

the effect of the irradiation. This applies especially to carcinoma of the cervix where radiation therapy is most frequently used. Very recently, Mansur[3] arrived at the conclusion that ureteral obstruction must be assumed as a "definite hazard" and that it represents "a frequent aftermath of heavy irradiation of the cervix."

The series of these articles was apparently started by Bugbee[4] when, in 1934, he published a group of 8 cases which he nephrectomized following irradiation of the cervix for carcinoma. Some of these cases were treated by radium alone, others by a combination of deep roentgen therapy and radium. The dosage was admittedly smaller than that in current use and no bladder injury of any kind was noted. In a few cases radium needles were implanted around the cervix and into the proximal parametria. Four of the cases died within a short time after the operation and autopsy revealed the presence of carcinoma metastases in all. Two of them showed extension or metastasis of the carcinoma in the occluded ureter. Four patients were still alive at the time of the publication of the paper, one with definite recurrence and ascites. It is the author's opinion that the early breaking down of the tumor tissue after irradiation, with the rapid cicatrization which resulted, caused the early ureteral obstruction and also accounted for the ureterovaginal fistulae which occurred in 3 of the cases.

In subsequent publications, most of the evidence in support of the theory that ureteral obstruction is caused by irradiation was derived from autopsy findings. Although the observations were usually limited to individual cases, the fibrosis encountered around the ureters and elsewhere within the pelvis has induced not a few of the investigators to assume that in the absence of any residue of the malignant neoplasm such a process is solely the sequela of irradiation. In particular, Mansur[3] became convinced that the obstruction is the result of compression by scar tissue rather than actual contracture of the ureter itself. He studied clinically and examined postmortem a case irradiated for carcinoma of the cervix in which, despite a mild reaction, a firm scar tissue mass was found nine months later to have obstructed both ureters. When the fibrous band about the ureters was cut, a fairly good opening of the lumen was found on each side, although some fibrous contracture had taken place within the walls. Wigby[5] likewise observed clinically and at autopsy a case of cancer of the cervix which following combined roentgen and radium irradiation developed bilateral hydronephrosis and died eleven months later. The marked thickening of the structures around the lower ureters without any trace of the former cancer suggested fibrosis incidental to radiation treatment, but in this case at the same time there was evidence of marked third degree reaction of the lower bowel, and the whole pelvis was a hard mass containing rectum, vagina, uterus, bladder and surrounding tissues.

Because of the frequency with which complications of the urinary apparatus are apt to occur, especially in connection with carcinoma of the cervix, several authors concentrated their attention on routine preliminary urologic studies to determine if some of the ureteral obstruction ordinarily attributed to the effect of irradiation might not have been present before the institution of any treatment at all. Graves and Kickham[6] investigated urologically and by postmortem examination a series of 174 cases of cancer of the cervix, belonging to clinical Stage III and IV, and they found positive signs of ureteral obstruction in 123 cases, or 70.7 per cent. Of these, 46 were in Stage III and 77 in Stage IV, indicating that the farther the cancer had progressed, the more

[3] Mansur, E. E. Ureter and its involvement in pelvic irradiation. *Radiology*, 1944, *43*, 147–154.

[4] Bugbee, H. G. Ureteral occlusion following radium implantation into the cervix. *J. Urol.*, 1934, *32*, 439–448.

[5] Wigby, P. E. Post-irradiation stricture of rectum and sigmoid following treatment for cervical cancer. Am. J. Roentgenol. & Rad. Therapy, 1943, *49*, 307–320.

[6] Graves, R. C., and Kickham, C. J. E. Urological complicatirns of carcinoma of the cervix. *Am. J. Surg.*, 1937, *38*, 168–172.

frequent became the urinary complications. The obstruction, as a rule, was encountered at a point 4 to 6 cm. above the bladder where the ureter lies beneath the broad ligament and adjacent to the cervix. Valk[7] in 1942, undertook a systematic study by means of retrograde and intravenous urography in 50 women afflicted with cancer of the cervix, 44 of whom were in clinical Stage IV. He, too, found that in 64 per cent of these women a definite upper urinary tract disease, varying from unilateral hydronephrosis to bilateral non-visualization was already present at the first urological examination, before any radiation therapy was started. By continuing the systematic examinations periodically after the completion of the irradiation series, he further found that instrumental dilation of the involved ureters could in no case produce regression of the hydronephrosis when once established, even if the cancer was eradicated, although temporary symptomatic amelioration was often obtained. It may appear of some significance in connection with these observations that Cosbie[8] who, in the same year, published the autopsy findings from an entirely different source found that of 24 cases of cancer of the cervix who died despite the radiation therapy given, in 17, or 70.8 per cent, there was ureteral obstruction associated with hydronephrosis or pyonephrosis. In every case the obstruction was the result of malignant infiltration of the cellular tissue.

Jaffe, Meigs, Graves and Kickham[9] extended their systematic urologic investigations to cases of all clinical stages and followed them through in those who survived for a period of five years or longer. These authors have chosen a group of 70 patients with cancer of the cervix treated by irradiation at the Pondville Hospital and have examined them by means of cystoscopy, catheterization of the ureters, whenever possible, and by retrograde and intravenous urography. The examinations were made prior to the institution of the treatment and at more or less regular intervals thereafter. Five of the patients belonged in Stage I, 3 in Stage II, 43 in Stage III and 19 in Stage IV. At the initial examination, there was positive evidence of ureteral obstruction in 25 cases, or 35.7 per cent of the entire group. None of the cases in Stages I and II showed an involvement of the ureters in the beginning and they remained negative throughout the followup period. According to the authors, this is a very important observation since it indicates that ureteral obstruction is not due to radiation effect on the ureteral wall. In 2 cases of Stage III there was a normal appearing urinary tract prior to the treatment, but unilateral obstruction developed in one twenty-one months after irradiation and bilateral obstruction in the other seven months after irradiation. Following instrumental dilation both cases promptly recovered and they are well five years and eight months, and six years after treatment respectively. This fact seems to indicate that the ureteral obstruction in the two cases was the result of replacement fibrosis of the carcinomatous infiltration of the broad ligament, as a result of the radiation therapy given. In those instances of Stages III and IV, in which the involvement of the ureters was present at the beginning, apart from temporary symptomatic improvement, no regression of the hydronephrosis could be obtained by the urologic treatment. The patients died of uremia even if irradiation had led to a complete eradication of the carcinoma.

There are only a few animal experiments available to substantiate the clinical observations. In 1926, Martin and Rogers[10] demonstrated that a dose of 75 milligram-hours yielded by two 6.25 mg. monel steel radium needles placed on either side of a dog's ureter produced complete occlusion

[7] Valk, W. L. Urological complications of carcinoma of the cervix. *J. Urol.*, 1942, *47*, 686–688.

[8] Cosbie, W. G. Complications of irradiation treatment of carcinoma of the cervix. *Am. J. Obst. & Gynec.*, 1941, *42*, 1003–1008.

[9] Jaffe, H. L., Meigs, J. V., Graves, R. C., and Kickham, C. J. E. Ureteral and renal complications of carcinoma of the cervix; their classification and management. *Surg., Gynec. & Obst.*, 1940, *70*, 178–184.

[10] Martin, C. L., and Rogers, F. T. Effect of irradiation on the ureter. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 215–218.

and hydronephrosis. But a subsequent experiment with a heavily filtered radium capsule showed that 2.5 threshold erythema doses applied directly to the ureter produced no damage. Recently Hueper and his coworkers[11] performed a series of experiments on dogs to study the radiation effect on the bladder. Although they were able to produce severe radiocystitis, no damage was reported to the ureters. Obviously, additional careful investigations are necessary before the question is definitely settled.

A correlation of the above enumerated data permits several conclusions. (1) Ureteral obstruction occurs so frequently in all malignant neoplasms located within the pelvis that it must be considered as a natural sequence during the later stages of the disease. There can be no doubt that many instances attributed in the literature to the effect of the irradiation belong in this category, especially if no systematic urologic studies anteceded the treatment. (2) Once a hydronephrosis or pyonephrosis is established, the gradual destruction of the kidney leading up to terminal uremia can be delayed but not prevented with the means at our disposal today. Even complete eradication of the carcinoma by irradiation cannot stop this inevitable outcome. Therefore, the demonstration at autopsy of obstruction of the ureters by scar tissue in the absence of any residue of the malignant tumor does not constitute proof that the irradiation is the responsible factor. If prior to the treatment the urologic findings were entirely negative, one may assume that the fibrosis is part of the healing process. (3) Gross overdosage or faulty technique may undoubtedly lead to fibrotic obstruction of the ureters but if such is the case a marked fibrosis with severe mucosal reactions must be encountered throughout the entire irradiated volume of the pelvis. Exception is made to the interstitial radium puncture where it is conceivable that some needles are inserted so close to the ureters that damage results locally. However, with the dosage and technique as used at present in routine radiation practice no injury is done to the ureters themselves. The fact that the obstruction is always noted in the anatomic proximity of the broad ligament, that is 4 to 6 cm. above the lower ureteral orifice, suggests that the effect must occur secondarily from processes in this region. The non-involvement of the urethra which during the same course of irradiation is often subjected to even larger doses than the ureters and the wholly unknown obstruction of the upper ureters when irradiation of the abdomen is undertaken for some other reason would also tend to support such a view. (4) It is assumed by several authors that the periureteral fibrosis in those instances in which the initial urologic examination was negative and ureteral obstruction developed months or years after treatment is the result of replacement of the carcinomatous permeation of the broad ligaments by scar tissue incidental to irradiation. There is, however, also the factor of a secondary infection of the carcinoma to be considered. It is common knowledge that all infections of the abdomen and pelvis heal with marked adhesions and there is no reason why this should not be true also in the case of a healing infected cancer. The importance of secondary infection in carcinoma of the cervix was studied in detail by Cosbie.[8] By taking routine cultures from the cervix of 243 patients, he found that of 47 patients with positive hemolytic streptococcus cultures, 25 developed some complications subsequently, consisting of pyometria, cellulitis, thrombophlebitis, pelvic abscess, peritonitis and septicemia. In another series of 176 patients, routine anaerobic cultures were taken. Of these, 72 showed positive infection and 32 developed inflammatory complications later. The cultures of 129 patients were negative and even in this group 28 developed some sort of an infection later. It is probable that in

[11] Hueper, W. C., Fisher, C. Virginia, de Carvajal-Forero, J., and Thompson, M. R. Pathology of experimental roentgen-cystitis in dogs. *J. Urol.*, 1942, *47*, 156–167.

not a few of the cases reported in the literature, the fibrosis observed around the ureters and elsewhere in the pelvis is the result of the natural healing of the infection following eradication of the carcinoma by the irradiation. Such viewing of the problem has also a practical significance. It may stimulate in the future experimentation with the newer sulfa drugs or penicillin, which, if administered in conjunction with irradiation, may lead, through rapid clearing up of the infection, to reduction or prevention of the fibrosis and thus of the ureteral obstruction.

Taken as a whole, there is insufficient proof to warrant affirmation that obstruction of the ureters is the direct or indirect result of irradiation as used in current practice for the treatment of malignant neoplasms situated within the pelvis. In fact, as newer evidence accumulates, the conviction grows that the opposite is true.

T. Leucutia

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: 1945, canceled.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago.

Section on Radiology, American Medical Association
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1945, to be announced.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. Earl R. Miller, University of California Hospital, San Francisco, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Roy W. Johnson, 1407 S. Hope St., Los Angeles, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. F. H. Squire, 1754 W. Congress St., Chicago 12, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. D. D. Brannan, 11311 Shaker Blvd., Cleveland 4, Ohio. Meets at 6:30 P.M. at Allerton Hotel on fourth Monday each month, October to April, inclusive.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meetings held in Dallas on odd months and in Fort Worth on even months, on third Monday, at 7:30 P.M.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida Radiological Society
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meets annually second Sunday in May.

Iowa X-Ray Club
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. R. Brindle, 501 Grand Ave., Asbury Pk. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. An

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

nual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Next annual meeting, Hotel William Penn, Pittsburgh, May 5–6, 1945.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. L. M. J. Freedman, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary Dr. A.M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Diego Roentgen Society
Secretary, Dr. Henry L. Jaffe, Naval Hospital, Balboa Park, San Diego, Calif. Meets monthly on first Wednesday at dinner.

San Francisco Radiological Society
Secretary, Dr. Carlton L. Ould, University of California Hospital, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Asa E. Seeds, Baylor Hospital, Dallas, Texas. Next annual meeting, Temple, Texas, Jan. 17, 1945.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly, third Thursday evening.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month at 4:45 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. J. W. McKay, 1620 Cedar Ave., Montreal, P. Q.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

MINNESOTA RADIOLOGICAL SOCIETY

The Annual Meeting of the Minnesota Radiological Society was held at Rochester, Minnesota, on April 13, 1944. At this meeting, Dr. Ralph S. Bromer of Bryn Mawr, Pennsylvania, delivered the Carman Lecture and was the guest speaker at the annual dinner. The following officers were elected for 1944–1945: *President*, K. Wilhelm Stenstrom, Ph.D., Minneapolis; *Vice-President*, Dr. Russell W. Morse, Minneapolis; *Secretary-Treasurer*, Dr. Annette T. Stenstrom, Minneapolis.

The Fall Meeting was held in Minneapolis on December 9, 1944, at the Nicollet Hotel. At the scientific session in the afternoon the following papers were read: "Radiation Therapy of Mastitis," by Solveig Berg, M.D. "X-ray Treatment of Malignant Tumors of the Testis and Results of Treatment," by G. M. Kelvey, M.D. "Bone Metabolism," by Edward Flink, M.D. The dinner at the Nicollet Hotel in the evening was given in honor of Dr. Leo G. Rigler, Professor of Radiology at the University of Minnesota. At this time, the Leo G. Rigler Fund of $11,000 was presented to the University of Minnesota to establish the Leo G. Rigler Lectureship in Radiology. This fund was raised by former pupils and colleagues and friends of Dr. Rigler. Dr. Fred J. Hodges of the University of Michigan was the first lecturer of this series. His subject was "The Teaching of Radiology."

ANNETTE T. STENSTROM
Secretary-Treasurer

LEO G. RIGLER—AN APPRECIATION

Over one hundred friends of Dr. Leo G. Rigler gathered at a special dinner in Minneapolis, December 9, 1944, to wish him well. The occasion was the Fall Meeting of the Minnesota Radiological Society, and the guest speaker was Dr. Fred J. Hodges, Professor of Roentgenology, University of Michigan, whose subject was "The Teaching of Radiology." Dr. Walter J. Ude, representing the Minnesota Radiological Society and friends of the honored guest, presented over $10,000 to the University of Minnesota to establish the Leo G. Rigler Lectureship in Radiology. This was accepted by Dean H. S. Diehl. Speakers were Dr. Robert G. Allison, Dr. George E. Fahr, Dr. E. T. Bell, and others. For some time the radiologists have wanted to express to Dr. Rigler their appreciation for his untiring efforts in their behalf. When his friends in other branches of medicine heard of this proposal, they too wanted to help. The sum accumulated so rapidly that it quickly reached the desired amount.

Leo George Rigler was born October 6, 1896, in Minneapolis. He attended the University of Minnesota, from which he received his M.D. degree in 1920. Following an internship in St. Louis City Hospital, St. Louis, Missouri, and practice in North Dakota, he was named Teaching Fellow in Internal Medicine, University of Minnesota (1921–1922). The following year he was appointed Roentgenologist at Minneapolis General Hospital, largely as the result of his interest in the roentgen diagnostic aspects of medicine. He was named Associate Professor of Radiology in 1927, and Professor in 1929. In 1935 he became Chief of the Department and has served in that capacity up to the present. In 1930 the State Board of Institutions made him a consultant. In 1941 the Minneapolis General Hospital named him Chief of the Department of Roentgenology. Prior to accepting the departmental appointment, Dr. Rigler completed his studies in Europe, spending most of his time with Professor Gösta Forssell in Stockholm, Sweden. There he also learned to speak Swedish.

Dr. Rigler is a member of Alpha Omega Alpha, Sigma Xi, American Medical Association, Hennepin County Medical Society, Minnesota State Medical Association, Minneapolis Academy of Medicine, Minnesota Academy of Medicine, American Roentgen Ray Society, Radiological Society of North America, Minnesota Radiological Society, American College of Radi-

ology (fellow), American Association of Thoracic Surgery and the American Association for the Advancement of Science. He is married (Matil Sprung, 1920), and has three children, Stanley, Nancy and Ruth. Dr. Rigler is the author of "Outline of Roentgen Diagnosis" (Lippincott), Second Edition, 1943, and many scientific papers.

As long as any of us can remember, Leo Rigler has been doing things for other people. The list is long and impressive. He has arranged and organized departmental conferences with most of the other departments in the hospital, as well as with the pre-clinical branches. He is always ready and willing to speak at medical gatherings and to teach special courses at the Center for Continuation Study. His contributions to graduate training include service not only to members of his own department but to practically every other clinical department. He has been instrumental in putting life and vigor into the Minnesota Radiological Society and he has been active in the councils of national associations. In recent years he has made a large contribution to War-Time Graduate Medical Meetings through his visits to all the hospitals in our area. It is at clinical pathological conferences that he is at his best, standing in front of the group, calling attention to what he sees and giving his conclusions just ahead of the pathologist with his postmortem report. He has been associated with roentgenology during its greatest period of development, and he has made a significant contribution to this specialty.

It is just and fitting that this honor should come to Dr. Rigler. The University of Minnesota has been a better place because of his contributions and all of us look forward to profitable years of association with him.

William A. O'Brien
Director of Post Graduate Medical Education
University of Minnesota

DR. W. D. COOLIDGE RETIRES, BUT CONTINUES AS X-RAY CONSULTANT

Under the above title appears a news item of interest to all radiologists. It is from the *Victor News* of January, 1945, and is quoted in part as follows:

President Charles E. Wilson recently announced the retirement of Dr. William D. Coolidge as vice-president and director of the General Electric research laboratory, a position he has held since 1940.

Dr. C. G. Suits, assistant to the director, has been elected a vice-president and in that capacity will be in charge of the company's research laboratory.

The announcement of his retirement does not mean that Dr. Coolidge is divorcing himself entirely from his chosen field of work—the science of x-ray. Instead, he will devote himself to activities as research and engineering consultant to the General Electric X-Ray Corporation in Chicago.

Entering the General Electric Research Laboratory in 1905, Dr. Coolidge became assistant director in 1908, associate director in 1928, director in 1932, and vice-president and director of research in 1940. Outstanding through the years was his resourcefulness in experiment.

That Dr. Coolidge's discoveries and inventions have wrought a profound change in our way of life is inescapable. He has obtained 83 patents himself, and indirectly his guiding influence has accounted for many other scientific triumphs to help mankind.

Dr. Coolidge is probably best known for his development of the Coolidge hot cathode x-ray tube, which followed his fundamental research in, and development of, ductile tungsten.

Many were the problems he had to solve before he finally attained his goal. But triumph he did, and the Coolidge x-ray tube soon substantially superseded all previous types. And the use of x-rays became a science instead of an art.

Honors have been bestowed upon him through the years, including an honorary M.D. degree from the University of Zurich which he received in 1937.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

THE HISTORY OF MINERS' DISEASES: A MEDICAL AND SOCIAL INTERPRETATION. By George Rosen, M.D. With an Introduction by Henry E. Sigerist, M.D. Cloth. Price, $8.50. Pp. 490, with illustrations. New York: Schuman's, 1943.

This book of almost five hundred pages at once aroused the reviewer's curiosity as to why such a voluminous publication should be devoted to a field apparently as narrow as the history of miners' diseases. Unfortunately, the historical development of any disease is too often considered to be of little importance by many physicians. This is probably why, in systems and textbooks of medicine, such material is placed in small type, and allotted only one or two brief paragraphs at the most. In some instances, moreover, the reviewer is suspicious that even these references are composed of a few random notes unenthusiastically copied from some handy source without proof of their authenticity. When thus garnered and recorded without careful evaluation, they are likely to contribute little except perhaps, in some instances, the perpetuation of historical errors.

The publication, therefore, of such a text by Dr. Rosen with the approval and commendation of an authority with the standing of Henry E. Sigerist of the Johns Hopkins Institute of the History of Medicine, merits the attention of the profession at large. This is not only on account of the information made available and the enjoyable reading which the volume provides, but also because it stimulates one to contemplate carefully the motive underlying the preparation and publication of such an exhaustive treatise in this field. This is adequately recorded in the preface by the author. In brief, it is to trace the growth of knowledge concerning the diseases which affect miners and to correlate this information with the advances in the basic medical sciences as well as with the varying social and economic conditions which have contributed to the rise of occupational disease among miners. I have no idea if the author had the following thought in mind but he could have said, very properly: the purpose of the book is to emphasize that one does not really have a sound and comprehensive grasp of any subject unless he goes back to the beginning and acquires a thorough knowledge and understanding of its development, step by step. Furthermore, not only must one have accumulated information dealing with the disease itself, but also of the conditions, socially and economically, which may have played a rôle in contributing to it. In other words, by example, this study is a lesson in scholarly thoroughness in the acquisition of information as opposed to the commonplace superficiality of knowledge which is all too prevalent.

One cannot study parts of history in any era and attain an adequate conception of what has taken place. The more erudite approach would be an attempt to learn something of all phases of man's activities during any given period. Undoubtedly, the historians might also benefit in the understanding and orientation of their subject of investigation if they too devoted more attention to all of the aspects of the period in which they are interested. This, for example, should include such medical matters as the effect of illness and death upon crucial decisions of monarchs or statesmen, and their effects on the morale and demeanor of the populace.

In many respects, the situation in historical research, and the evaluation of data pertaining to it, reminds me somewhat of the dangers inherent in highly developed medical specialism where, in some instances, members of our profession attempt to take care of parts of people. It is generally conceded that this procedure is fraught with danger.

No attempt will be made to review the contents of the entire book. I will, however, vouch for the statement that the subject is covered thoroughly in all of its aspects from neolithic times to the end of the nineteenth century. This includes such historical phases of miners' diseases as the morbidity and mortality, pathology and nosography, therapy and prophylaxis, and the beginnings of social and protective legislation. Certainly anyone desirous of obtaining a sound understanding of all diseases to which miners are subject should begin his studies with this treatise.

There were two individuals discussed in this book with whom I was not familiar historically, who especially attracted my attention. The first was Bernardino Ramazzini, an eminent Italian physician of Mondena who lived between the years 1633 and 1714. In 1700 he published the first treatise on occupational diseases, *De morbo artificum diatriba*, which served two useful purposes: first, it summarized all knowledge on occupational diseases up to the eighteenth century, and second, it provided an excellent basis for future study. In addition to his knowledge of occupational diseases, Ramazzini must have been a clinician of considerable ability. At least he imparts some sound advice which, if followed more closely even today, would avert some diagnostic errors in medicine. He says . . . "when a physician visits a patient, he ought to inquire into many things by putting questions to the patient and the bystanders. You must ask . . . what uneasiness he is under, and what is the cause of it, how many days he has been ill, how his belly is affected and what food he eats," . . . to which I would presume to add one interrogation more: namely, "what trade is he of."

In perusing this monograph, one cannot help but admire also the work of J. Arnold who in 1885 published by far the most extensive study of experimental pneumoconiosis which had appeared up to that time. Although previous workers had contributed to this field, it was apparently Arnold who did the thorough job. In his attempts to produce pneumoconiosis in animals, he exposed rabbits to a dusty atmosphere for as long as eight hours daily, over a period of 417 days; in the case of dogs, the time of exposure was twenty-four hours daily for 806 days. His experiments did much to advance our knowledge in this field. It is amazing how often many clinical observations will be made concerning a disease and countless pages will be written dealing with the theoretical possibilities relating to its cause and mechanism of production, but so much time is required before someone has the initiative or insight to learn definite facts by attempting to produce the disease experimentally.

In conclusion, the reviewer makes the following comments: One should read Dr. Rosen's contribution to medical history (1) if he is interested in obtaining a thorough background for the study of occupational diseases and especially those associated with mining, (2) if he has an interest in medical history with its many ramifications, and finally (3) if he has the desire to become acquainted with effective methods of research in topics dealing with medical history, and the presentation of the findings in an attractive and readable fashion.

Cyrus C. Sturgis

Roentgen Treatment of Diseases of the Nervous System. By Cornelius G. Dyke, M.D., F.A.C.R., Associate Professor of Radiology, College of Physicians and Surgeons, Columbia University; Director, Department of Radiology, Neurological Institute of New York, and Leo M. Davidoff, M.D., F.A.C.S., Chief, Department of Surgery, Attending Neurological Surgeon, Jewish Hospital of Brooklyn. Cloth. Price, $3.25. Pp. 198, with 12 illustrations. Philadelphia: Lea & Febiger, 1942.

The authors open their treatise with a discussion of the effect of radiations on the normal nervous system quoting evidence from the earliest experimenters. After presenting the general literature on the effect of roentgen and radium rays on pathologic nervous tissue, the techniques of Dr. E. P. Pendergrass, Dr. Sherwood Moore, Dr. M. C. Sosman, and Drs. Alexander Brunschwig and Anna Hamann are presented. This is followed by a detailed presentation of the authors' technique in the treatment of various pathologic conditions of the nervous system. Their results are then presented in detail. The world literature on the subject of irradiation of the nervous system is reviewed in this relatively small volume.

For anyone who is interested in the treatment of diseases of the nervous system by irradiation, the book should be extremely valuable, for it covers not only modern techniques but also the world literature on the subject.

H. Dabney Kerr

Physical Foundations of Radiology. By Otto Glasser, Ph.D., Professor of Biophysics and Head of Department of Biophysics, Cleveland Clinic Foundation, Cleveland, Ohio; Edith H. Quimby, Sc.D., Associate Professor of Radiology (Physics), College of Physicians and Surgeons, Columbia University, New York; Lauriston S. Taylor, Ph.D., Chief of X-Ray Section, National Bureau of Standards, Washington, D. C.; and J. L. Weatherwax, M.A., Philadelphia General Hospital, and Graduate School of Medicine,

University of Pennsylvania, Philadelphia. Cloth. Price, $5.00. Pp. 426, with 95 illustrations. New York: Paul B. Hoeber, Inc., Medical Book Department of Harper & Brothers, 1944.

The format of this book is excellent. Special attention should be called to the durable binding, neat, well arranged chapter headings and the position of the illustrations in close proximity to their descriptive material.

Subjects covered include a discussion of the concept of matter, roentgen-ray apparatus, character of the roentgen-ray beam as to quality and quantity with respect to both roentgenography and therapy. The last two chapters are concerned with radium dosage and protection methods for radium and roentgen rays.

A few fundamental equations necessary for basic understanding of the physics of radiology are stated in their simplest form with full explanation of each symbol and equation.

The book is a combination of text intended for beginners in radiology and tabulations of data suitable for the fully trained practitioner and advanced worker. It is inevitable that there is some conflict. As a compilation of practical, useful data—constants and numerical rules needed every day in a busy department and essential to any good teaching course—the book is invaluable and fills a need of long-standing.

H. S. Hayden

Technic of Electrotherapy and Its Physical and Physiological Basis. By Stafford L. Osborne, M.S., Ph.D., Assistant Professor, Department of Physical Therapy, Northwestern University Medical School, and Harold J. Holmquest, B.S., B.S.(M.E.), Lecturer in Applied Physics, Department of Physical Therapy, Northwestern University Medical School, Chicago. Cloth. Price, $7.50. Pp. 780, with 240 illustrations. Springfield, Illinois: Charles C Thomas, 1944.

Two men singularly equipped for the writing of a text dealing with the technic of electrotherapy and its physical and physiological basis have joined their efforts in the preparation of this book. Sixteen years of experience in the teaching of the subject matter at Northwestern University form the background of the method of presentation. The material is divided in four major chapters: direct current; muscle stimulation by electric currents; radiation, and high frequency currents. Each has appropriate subdivisions, usually starting with general considerations followed by thorough discussions of the apparatus used and of the technic of application of each therapeutic agent. The references to the literature are ample and the illustrations well chosen. One suggestion might be given for future editions. The spreading of footnotes over several pages sometimes separated by an interspaced illustration with legend—see pages 320–323 and pages 429–436—disrupt the continuity of the text. It would facilitate reading to have footnotes of such length incorporated in the main text. Otherwise the reviewer agrees with the last sentence in John Coulter's foreword: "It is indeed a book of fundamental worth."

Ernst A. Pohle

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DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

TECHNIQUE OF ROENTGENOGRAPHY OF THE CONDYLES OF THE MANDIBLE

By MAJOR JAMES M. DELL, JR.
Medical Corps, Army of the United States

THE purpose of this article is not to present something new, but to emphasize the value of an old technique for roentgenography of the condyles of the mandible. This technique is particularly adapted to a study of the condyle, its articular surfaces, and adjoining ramus. The technique was described by W. W. McQueen in the *Minneapolis District Dental Journal*, September, 1937, who used it in the study of the temporomandibular joint. Due to the direction anatomically of the temporomandibular fossa, this technique is not as valuable as the modified Law mastoid position. It has proved very valuable in the

Fig. 1

Fig. 4

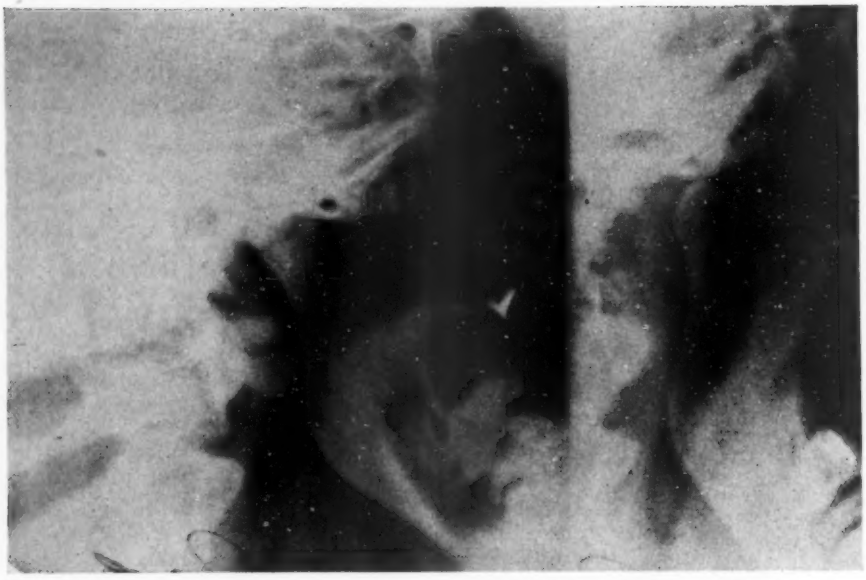

Fig. 2

study of fractures involving this area as well as pathological changes in the articular surface of the condyle. The technique described by McQueen involves the use of a dental machine whereas the present technique uses the Picker Army Field Unit. As the field unit is widely available to the Armed Services it is thought that this technique may prove of some value.

The patient may be placed either in the

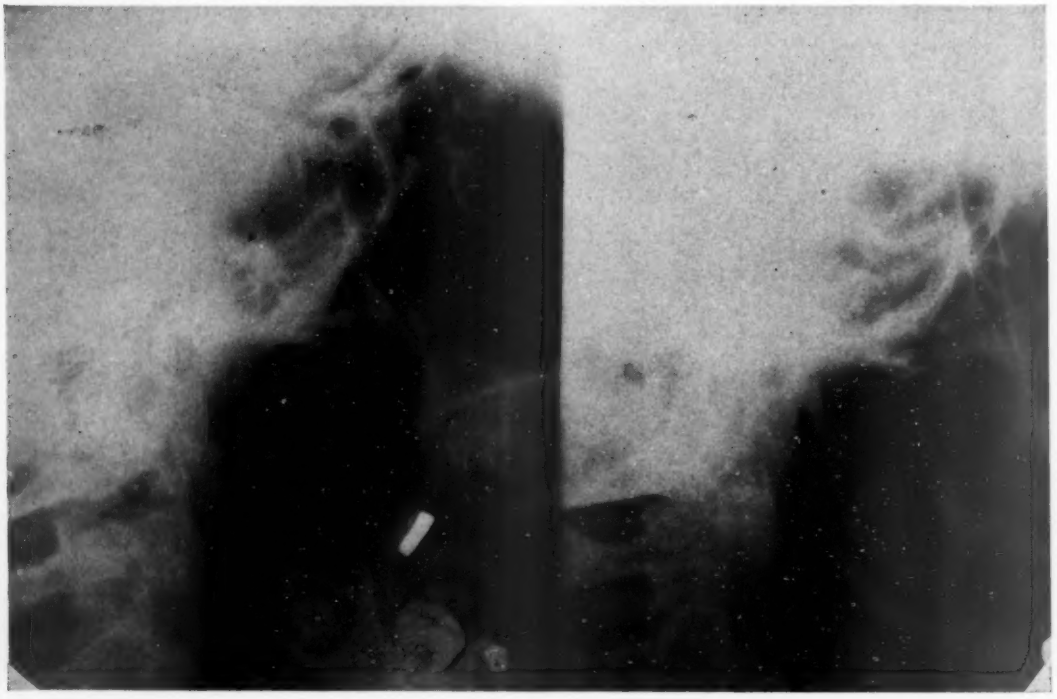

Fig. 3

sitting or recumbent position. The central ray is directed through the mandibular notch on the opposite side of the joint to be taken. The mandibular notch is best located at a point just below the zygomatic arch and about 2 cm. anterior to the posterior border of the ramus. The tube head is brought down almost to contact with the skin. An 8 by 10 inch cassette is placed on the side to be examined parallel to the sagittal plane of the head. The head is held in a true lateral position relative to the cassette. The central ray is directed 5 degrees posteriorly and 5 degrees superiorly centering on the joint nearest the cassette. One exposure is made with the mouth closed and one with the mouth open. The articular surface is usually visualized better in the open mouth position.

Figure 1 illustrates the condyle with the closed mouth. Figure 2 illustrates the closed and open mouth positions. Figure 3 shows the open mouth position. Figure 4 demonstrates an apparent osteochondritis dissecans in the condyle. Several fracture cases were unavailable for reproduction. The illustrations show the structures that can be visualized by this method.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

Abdomen

Guyer, R. B. The comparison of radiological and gastroscopic findings in 200 dyspeptic soldiers. *Brit. J. Radiol.*, 1943, *16*, 241–246.

Dyspepsia has been a frequent cause of disability in soldiers during this war. The author reports the roentgen and gastroscopic findings in 200 cases in soldiers nineteen to forty-eight years of age. The technique of the two forms of examination is described and the findings in various pathological conditions of the stomach and duodenum compared. It was found that gastroscopic examination was the most useful in the diagnosis of gastritis. This is readily explained. The roentgenologist examines the stomach as a whole, and his diagnosis is based on estimation of function and examination of the coarser anatomical details. But the gastroscopist can make a close examination of the changes in the mucous membrane and see any early inflammatory changes that are taking place, as well as the more obvious organic lesions such as ulcer and malignant disease.

Roentgenology still stands supreme in the examination of the duodenum as this organ is inaccessible to the gastroscopist. Cases with duodenal ulcer gave normal gastrocospic findings in 50 per cent of the cases while in those with duodenitis only 1 out of 14 was normal. The finding of gastric changes on gastroscopy is therefore corroborative of the roentgen diagnosis of duodenitis rather than actually diagnostic in itself.

There are two other types of cases in which gastroscopy is extremely valuable: (1) cases of healed or healing gastric ulcer in which the changes have passed beyond the stage where they can be demonstrated roentgenologically, and (2) cases of early malignant disease in which the changes have not yet become pronounced enough to be demonstrated on roentgen examination.—*Audrey G. Morgan.*

Johnstone, A. S. A radiological sign of pyloric stenosis. *Brit. J. Radiol.*, June, 1943, *16*, 169.

Differentiation between true pyloric stenosis and pylorospasm is often difficult. The best position for taking roentgenograms for this purpose is the supine with the left side slightly raised. It has been found that in roentgenograms taken in this way if there is stenosis of the pylorus there is a clearly defined shadow representing the thickness of the stomach wall along the greater curvature, the mucosa being lined with barium and the peritoneal surface showing as a fine line which becomes more noticeable if there is gas in the transverse colon. If the correct technique is used with a rotating anode, a moving grid and a kilovoltage slightly lower than that usually used with barium meals the shadow should be visible at some point along the distal two-thirds of the greater curvature in all cases of hypertrophy. Accurate measurement of the thickness of the wall cannot be made, but if the soft tissue shadows measure over 4 mm. hypertrophy is probable and if they measure over 5 mm. it is certain.—*Audrey G. Morgan.*

Hodson, C. J. A case of intestinal obstruction due to gallstones. *Brit. J. Radiol.*, June, 1943, *16*, 185.

A woman past eighty with no history of abdominal symptoms was seized with violent abdominal pain, frequent vomiting and later collapse. A clinical diagnosis of obstruction of the small intestine by impacted gallstones was made. Roentgen examination showed four rounded, laminated shadows, two in the right hypochondrium close together and two in the right iliac fossa about 3 inches apart. It was thought probable that two of the stones were in the gallbladder and two in the lower ileum. They hardly seemed large enough to cause obstruction but it was thought that they might have a non-opaque cortex, which proved to be true. Laparotomy was performed the following day and the large stone at the lower end of the ileum removed. Later the others were passed naturally. The patient made an uneventful recovery.

The case shows the value of the plain roentgenogram in the diagnosis of serious abdominal conditions and also illustrates the variations in

opacity of gallstones and calls attention to the necessity of making allowance for this in such examinations.—*Audrey G. Morgan.*

Brailsford, James F. The radiographic findings in idiopathic steatorrhoea. *Brit. J. Radiol.*, Sept., 1943, *16*, 283–285.

The condition known as idiopathic steatorrhea or non-tropical sprue is very similar to celiac disease of infants. It shows characteristic roentgen changes in the small intestine and bones and the clinical symptoms of hypocalcemia and avitaminosis. The clinical and roentgen findings indicate disturbances in the metabolism of fat and calcium.

The normal roentgenographic appearance of the small intestine is described, and roentgenograms given showing the normal intestine and that in steatorrhea and the changes in the bones of the hands in this disease.

In the small intestine the appearance of the jejunum is normal at first but within half an hour the normal appearance has changed and the barium as long as it can be seen in the small intestine seems to be gathered into curds, some small and irregular and others filling isolated dilated segments. In other places, curd-like fragments will be seen in segments dilated with gas. Some distended coils may show a coarsely serrated periphery, while others show barium in shallow folds of mucous membrane which pass around the segments in rib-like fashion. This irregularity in tonicity of the intestine may be associated with more rapid flow than normal; within two hours some of the barium may be seen throughout the large intestine, even though half the barium is still in the stomach. Much gas may be seen in the large intestine. The normal appearance in the beginning followed by abnormality though barium is still passing from the stomach suggests that the change in the barium pattern is caused by some excretion produced by the entrance of the food into the intestine, though the derangement of the innervation of the muscularis mucosa which is usually given as the cause may be an accompanying feature.

The bones in idiopathic steatorrhea show decalcification. In some cases the picture may resemble that of renal rickets or hyperparathyroidism. The metaphyses of the ends of the long bones are of greater depth than normal, the ends of the diaphyses being blurred as in rickets. In the adult, general decalcification may be associated with deposition of calcium in the ends of the phalanges. The skull of the adolescent will show a fine, stippled osteoporosis while at a later age general decalcification may be associated with ill defined rounded islands of varying size and density; these islands do not occur in active hyperparathyroidism. The long bones bend under the weight of the body and incomplete fractures may appear on the convex surfaces. The bodies of the vertebrae tend to show disc compression on the upper and lower surfaces.

In the past the general physician has concentrated on the changes in the small intestine while the orthopedic surgeon has concentrated on those in the bones. An effort should be made to study the whole picture with the object of working out effective methods of treatment.—*Audrey G. Morgan.*

Baker, Joel W., and Carlile, Thomas. Solitary diverticulitis of the cecum. *J. Am. M. Ass.*, June 5, 1943, *122*, 354–356.

This is a relatively rare condition which is occasionally encountered when the diagnosis of appendicitis has been made. Thirty-seven cases of solitary diverticulitis of the cecum have been found in the American and British literature. Two additional cases are reported by the authors. The essential pathologic process in each case was in a solitary diverticulum that was demonstrated to be acutely inflamed at operation.

The differential diagnosis of solitary diverticulitis of the cecum is almost impossible to make preoperatively. In a majority of cases in this series, a preoperative diagnosis of appendicitis was made. The differential diagnosis and choice of procedure at operation are of utmost importance in minimizing the risk to the patient. Aside from appendicitis, cancer is the most frequent lesion of the cecum. In differentiating cancer from diverticulitis, the problem is facilitated if one keeps in mind the three types of malignant tumors of the bowel. Tuberculosis is the next most frequently encountered lesion of the cecum. As a rule, the ileum also is involved. Small tubercles can occasionally be seen on the serosa. The peritoneum is usually thickened. Actinomycosis of the bowel usually starts in the cecum or the appendix. The wall may be greatly thickened, and in later stages small abscesses are formed which may open through sinuses in the abdominal wall, discharging ghe characteristic sulfur granules. Nonspecific ulcers of the cecum are encountered with approximately the same frequency as

diverticula. They may be single or multiple. The problem encountered is the same as that in diverticulitis. There should be minimal surgery rather than wide resection. Simple inflammatory tumors of the cecum in which there was no definite etiology have been reported.

In 14 cases in this series, resection of the cecum and/or ascending colon was considered advisable, either because of the extent of the lesion or because the lesion was thought to be malignant or tuberculous.—*S. G. Henderson.*

Jenkinson, E. L., and Brown, W. H. Endometriosis; study of 117 cases with special reference to constricting lesions of the rectum and sigmoid colon. *J. Am. M. Ass.*, June 5, 1943, *122*, 349–354.

The importance of this disease as a cause of constricting lesions of the rectum and sigmoid colon has not been sufficiently stressed, nor is adequate roentgenologic information available. Constricting endometrial lesions are often confused with carcinoma, and patients sometimes are subjected to radical resection of the bowel, whereas castration usually will suffice. The term "endometriosis" in this discussion designates islands of ectopic adenomatous tissue with histologic and functional characteristics similar to that of normal endometrium and located in the female pelvis outside the uterine wall and cavity. Endometriosis of the sigmoid colon or rectum resembles endometrial lesions elsewhere. Implants usually occur on the serosal surface with subsequent involvement of the muscular coats. The mucosa only occasionally is invaded. An associated intense inflammatory reaction is always present.

About 25 per cent of all women with pelvic endometriosis have lesions of the rectosigmoid. Since approximately 15 per cent of all women develop endometriosis, it may be concluded that from 2 to 4 per cent of all women at some time during their active menstrual life may develop endometriosis of the sigmoid, rectum or rectovaginal septum. At this site it is a potential factor in causing a constricting or obstructing lesion of the colon and rectum. Of the 47 patients with rectosigmoid endometriosis found in the present series, 21 had symptoms indicating some degree of obstruction.

Endometriosis of the rectosigmoid is characterized by symptoms similar to other forms of pelvic endometriosis and by gastrointestinal complaints which depend on the duration of the lesion and the presence or absence of a constriction. Most patients have a relatively long duration of symptoms. The average duration in the present series was 2.8 years. A high incidence of sterility is usually considered a characteristic of endometriosis and associated pelvic disease. In the present series 40 patients complained of absolute sterility. Menstrual abnormalities are frequently found. In the present series 95 complained of dysmenorrhea of the acquired type, metrorrhagia or menorrhagia. The most frequent complaint of the 21 patients with obstructive symptoms was severe progressive constipation usually associated with pain in the low abdomen which was worse at menstruation. There may be few significant physical findings, depending on the location and extent of the lesion. Sigmoidoscopic examination may reveal narrowing of the lumen of the bowel with intact but puckered red and congested mucosa. The intact mucosa explains the low incidence of gross or occult blood which would not be accounted for by other anorectal diseases.

The barium contrast enema has been considered by some writers to be of little value in the diagnosis of constricting endometrial lesions of the rectum and sigmoid colon. The presence of positive roentgenologic signs depends on the extent of bowel involvement and on the location of the lesion. Two factors probably produce obstructing lesions: (1) the endometrial tumor which may involve the bowel wall sufficiently to compromise the lumen, although the mucosa rarely is invaded; (2) the intense inflammatory reaction, which is the principal basis for the roentgenologic findings. In differentiating this disease from carcinoma, exacerbation of symptoms coinciding with the menstrual period is confirmatory evidence of endometriosis. Typical roentgen findings in endometriosis of the rectosigmoid include a long filling defect with sharp regular borders, intact mucosa, inconstancy of the filling defect and fixation of the bowel, which is exquisitely tender to palpation. Carcinoma is characterized by a short filling defect, sharp irregular margins, ragged, moth eaten mucosa, constant filling defect and usually absence of fixation or exquisite tenderness on palpation. Infectious lesions usually may be differentiated clinically.

The treatment of endometriosis of the rectosigmoid is summarized by Cattell, who emphasizes the importance of conservative treatment in patients under thirty-five. He states that radical treatment is necessary in most cases in which there is involvement of the colon and rec-

tum. Such cases, irrespective of age, require removal of both ovaries. Pemberton restricts roentgen therapy to patients in whom conservative treatment to preserve the childbearing function has failed. All patients in the present series with constricting lesions of the rectosigmoid caused by endometriosis, when examined by barium enema more than two months after surgical castration, had complete restoration of the lumen of the bowel.—*S. G. Henderson.*

Robbins, Laurence L. The roentgenologic diagnosis of parasternal omental hernia. *Radiology*, Oct., 1943, *41*, 378–382.

Three cases of parasternal omental hernia seen at the Massachusetts General Hospital are described and illustrated with roentgenograms. In two cases the hernia contained omentum only and, in the other, large intestine also. The roentgen image of omental hernia sometimes resembles that of mediastinal tumor. Differentiation is important not only for the sake of accuracy but because of the possible necessity for operation. The diagnosis of parasternal omental hernia can be made from a combination of upward displacement of the large intestine and the stomach and the presence of a mass in the right anterior cardiophrenic angle.—*Audrey G. Morgan.*

Connolly, A. E. Endothelioma of the peritoneum. *Brit. J. Radiol.*, May, 1943, *16*, 153.

Primary tumors of serous membranes are rare. A case is described in a man of sixty-five first admitted to hospital June 29, 1937, complaining of abdominal pain and vomiting. Neither physical or roentgen examination showed evidence of tumor. He left the hospital free of symptoms after two weeks' treatment. He returned in November, 1941 complaining of abdominal pain, flatulence, loss of weight and vomiting. Roentgen examination showed gas-capped fluid levels in the intestine, as evidence of obstruction. Operation showed small secondary growths in the mesentery and small intestine. One such growth had caused complete obstruction at the lower end of the ileum. A lateral anastomosis was performed. The site of the primary growth was not determined. Recovery was uneventful. The clinical impression was that of carcinoma of the stomach with peritoneal metastases. The patient returned March 5 and roentgen examination indicated multiple obstructive lesions in the small intestine. Operation showed the mesentery, small bowel and great omentum covered with small white swellings. In the first 3 inches of the jejunum there were three hard white infiltrated areas that caused obstruction. They seemed to start on the mesenteric border and extend around the loop. A posterior gastrojejunostomy was done. A part of the omentum was removed for examination, which showed dilated lymphatics and proliferation of the endothelium. Uneventful recovery.

The endotheliomatous growth apparently originated in the subserous lymphatics, and invasion of the lower ileum caused obstruction by gradual narrowing of the lumen. The clinical course indicated that the tumor was benign. It may, however, cause fatal results from mere size even though the cells are not malignant.—*Audrey G. Morgan.*

GYNECOLOGY AND OBSTETRICS

Williams, Rohan. The radiological diagnosis of disproportion. *Brit. J. Radiol.*, June, 1943, *16*, 173–181.

Clinical examination of the pregnant woman should be supplemented by roentgen examination to determine whether there is any disproportion between the size of the fetal head and that of the fetus. This is particularly true in border line cases where there is any doubt from the ordinary obstetrical measurements.

The author describes in detail and illustrates a method of charting by means of two-projection reconstruction charts of the pelvis with which standard fetal head models are compared. The roentgenologist is particularly responsible for disproportion in the mid-plane and at the outlet of the pelvis. Sixteen cases are described and illustrated with charts. It is true, however, that it is impossible to calculate the force of uterine contraction, the capacity of the fetal head for moulding and the influence of the soft tissues on the flexion, extension and rotation of the fetal head and that therefore labor is often less difficult than would be indicated by the roentgen measurements.—*Audrey G. Morgan.*

Allen, E. Peter. The subpubic angle: radiological aspects. *Brit. J. Radiol.*, Sept., 1943, *16*, 279–282.

In view of the fact that the size of the subpubic angle is of definite obstetrical significance and a narrow angle causes delay at the pelvic outlet, it is a pity that so little is known of the roentgen measurement of this angle. Various techniques for the measurement of the angle

have been described but none of them is universally accepted. Some of the methods used have not been sufficiently described and illustrated and their use by anyone but the originator is apt to lead to mistakes. The errors inherent in various techniques have been unrecognized or their importance minimized. Until a standard technique has been adopted series of measurements made by different investigators cannot be compared and any series that have been made should be reviewed in the light of such standard technique.

The author recommends the preparation of a special roentgenogram by the method of Chassard and Lapiné which is described as follows by Roberts: " 'The patient is placed straddling a cassette . . . ; she is made to stoop forward till the under surface of the symphysis pubis and the ischial tuberosities are equidistant from the film, *i.e.*, the pubic arch is now horizontal. The tube is centred above or slightly posterior to the ischial tuberosities.' . . ." This roentgenogram should be checked by measurement of a standard lateral view of the pelvis and the measurement either of the subpubic angle direct or the measurement of the symphysis-biparietal distance by means of a transparency. If the angle is measured direct it should be measured as the angle made by two lines drawn from the lower edge of the symphysis tangential to the inner borders of the tuberosities.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

Hodson, C. J. Pyelography and the space-filling lesion; carbuncle of the kidney. *Brit. J. Radiol.*, March, 1943, *16*, 86.

A case is described in a young man twenty-two years of age who had pain in the left loin, chills, sweats, leukocytosis and fever. The following week a trace of albumin was found in his urine. An intravenous pyelogram showed deformity of the left renal pelvis with lack of visualization of the middle calyx and a slight impairment of function as shown by dye tests. The roentgen examination alone suggested tumor but the clinical symptoms indicated acute inflammation and a diagnosis of carbuncle of the kidney was made. Treatment was given with rubiazol 1 gm. every four hours for four days followed by intensive sulfathiazole treatment for five days which brought his temperature down to normal. Recovery was uneventful. A second roentgenogram nine days after the first showed improved function of the kidney and approximately normal anatomical conditions.

The case illustrates the importance of considering both roentgen and clinical findings in diagnosis.—*Audrey G. Morgan.*

Pendergrass, Eugene P. Excretory urography as a test of urinary tract function. Carman Lecture. *Radiology*, 1943, *40*, 223–246.

The author reviews the anatomy and physiology of the urinary tract, particularly the kidney and emphasizes the importance of correlating the kidney function tests and the urographic findings. The lecture is profusely illustrated with diagrams and roentgenograms illustrating the points he makes. It has been the custom for physicians and surgeons to think of excretory urography as a method of detecting pathological-anatomical anomalies in the kidney and to depend on the ordinary functional tests for information in regard to function. This is a great mistake and this form of examination should be considered essentially a functional test. Both tubular and glomerular function should be tested and there is some evidence that skiodan is more useful in testing glomerular function and diodrast in testing that of the tubules. The patient should be examined in the prone, erect, oblique and supine positions. Full details of the technique are given. The time required for clearance of the contrast medium is the test of kidney function. The ureters and bladder should also be included in the examination.

Urokymography is one of the methods that will probably be developed further in the examination of the urinary tract.—*Audrey G. Morgan.*

Adams, Payson. Radiopaque membranous pyelitis following sulfonamide therapy. *J. Am. M. Ass.*, June 12, 1943, *122*, 419–423.

Clinical and experimental reports of renal complications following the use of the sulfonamide drugs suggest their danger and the importance of meticulous observation. Sulfapyridine, sulfathiazole and, more recently and to a lesser extent, sulfadiazine are more prone to cause renal damage than is sulfanilamide. The slow absorption and relatively slow excretion and high solubility of sulfanilamide explain the infrequent occurrence of renal damage from this compound, whereas the very rapid absorption and excretion with resultant high concentration of the less soluble sulfapyridine and sulfathiazole in urine explain their relatively frequent production of renal complications. For the most

part, authors have indicated that sulfathiazole and sulfadiazine crystals precipitated within the renal pelvis and calices are highly soluble and will dissolve readily either under renal pelvic lavage with sterile distilled water through a ureteral catheter or spontaneously if the drug is discontinued and fluids are forced. Crystals precipitated within the renal tubules are not amenable to such therapy.

Two cases are cited in each of which partial or complete unilateral ureteral blockage by a small calculus was present. In each patient a radiopaque calcareous membrane formed on the epithelial surface of the calices and renal pelvis of the kidney on the involved side. Sulfathiazole in 1 patient and sulfadiazine in the other were thought to be at least partly responsible for this complication. Other factors, such as infection and obstruction, may have played a more important part, but similar cases have not been reported prior to the sulfonamide era.

The author concludes that sulfathiazole and sulfadiazine may cause rapid formation of a nonsoluble, calcareous, radiopaque membrane on the epithelial surfaces of the calices and pelvis if there is an associated ureteral stasis, pyelonephritis and alkaline urine. Therefore these drugs should not be given indiscriminately in such cases but, if thought mandatory, every effort should be made to prevent formation of such membranes by correcting ureteral stasis, maintaining renal drainage, improving the renal output and rendering the urine highly acid (pH 5.6 or less).—*S. G. Henderson.*

Hartung, Walter, and Flocks, Rubin H. Diverticulum of the bladder; a method of roentgen examination and the roentgen and clinical findings in 200 cases. *Radiology*, Oct., 1943, *41*, 363–370.

Diverticulum is a frequent and serious complication of obstruction of the neck of the bladder. The nature, extent and seriousness of such complications can be determined only by roentgen examination. The authors describe a method of examination for such obstructions that consists essentially of four films: (1) the flat film; (2) the opaque anteroposterior cystogram; (3) the air cystogram taken in the oblique position, and (4) the cystourethrogram. This examination gives a great deal of information in regard to the bladder and urethra. The flat film shows the presence or absence of metastatic lesions in the bones and of opaque urinary calculi. The sodium iodide cystogram shows the presence or absence of diverticula, ureteral flux, displacement of the bladder, irregularity of the bladder wall and filling defects due to tumors or enlargement of the prostate. The air cystogram shows the presence or absence of non-opaque bladder stones, enlargement of the prostate and cancer of the bladder. The cystourethrogram gives more information in regard to the nature of the enlargement of the prostate and also shows the presence or absence of any pathological process in the urethra. The examination shows the size and position of any diverticulum of the bladder, the size of its neck, its contents and the ease with which the diverticulum can be emptied. It also shows the results of operative treatment of the diverticulum. Roentgenograms of typical findings are given and a brief summary of the roentgen and clinical findings in 200 cases of diverticula of the bladder.—*Audrey G. Morgan.*

Colston, J. A. Campbell. Carcinoma of the prostate; study of percentage of cases suitable for radical operation. *J. Am. M. Ass.*, July 17, 1943, *122*, 781–784.

In the five year period between September 1, 1937 and September 1, 1942, a diagnosis of carcinoma of the prostate was made in 358 cases, of which 318 were admitted to the hospital. During this period 73 radical operations were performed, this being 20.2 per cent of all cases seen. The criteria for cases suitable for the radical operation are not absolute. They depend largely on careful rectal examination. The malignant growth should not extend beyond the capsule of the gland, into the membranous urethra or beyond the base of the seminal vesicles, and metastases must not be demonstrable either on physical or on roentgenologic examination. In addition, the serum acid and basic phosphatase must be within normal limits. An elevated acid phosphatase level in the blood serum should be interpreted as indicative of metastases from prostatic carcinoma unless some other definite cause for this elevation can be proved. No patient should be subjected to the radical operation unless the general physical condition is satisfactory, and the patient should have a fair span of life expectancy. There were 4 hospital deaths in the series of 73 operations—a mortality of 5.5 per cent. Of 43 patients for whom the prognosis was good, 41 are living and well without evidence of recurrence or metastasis. Of 26 patients for whom the prognosis was poor, 8 are living and well at intervals varying

from three months to five years. Intensive follow-up of all patients with early cancer of the prostate subjected to Young's radical operation shows that more than 50 per cent are free from recurrence or metastasis from five to twenty-seven years after leaving the hospital.—*S. G. Henderson.*

SKELETAL SYSTEM

Osmond, Leslie H. Correlation of disability with roentgen findings: head injuries. *Radiology*, July, 1943, *41*, 1–10.

Roentgenography of the skull, encephalography and ventriculography all help in demonstrating structural changes following trauma. Clinically, it is often difficult to determine what part is played in a disability by post-traumatic organic brain disease, post-traumatic neurosis or unrelated abnormalities. The methods mentioned above help to settle these questions, determine whether surgery is needed, establish a more accurate prognosis and show the degree of disability for which compensation can be claimed.

Roentgen examination immediately after a head injury is not always advisable; patients in shock should not be moved about on a roentgen table for fear of damage to the brain and intracranial blood vessels. The roentgen appearance of an old fracture may show evidence of sufficient pathology of the brain or meninges to explain varying degrees of disability. Other roentgen findings of significance are osteomyelitis, epidural and subdural hematoma, intracerebral hemorrhage, cerebral hemiatrophy with homolateral hypertrophy of skull and sinuses.

In the encephalogram injury to the brain following head wounds is shown by porencephaly, cerebral atrophy, arachnoiditis and scar formation. Porencephaly is the most characteristic change in brain trauma. Cerebral atrophy is somewhat less characteristic. All cases that the author has seen of porencephaly, unilateral cerebral atrophy and scarring of brain tissue have been associated with head injury except one case of bilateral internal porencephaly following a severe acute illness in infancy, but even in this case trauma could not be definitely excluded. The symptomatology in these conditions is not always in proportion to the structural change found.

Illustrative roentgenograms are given showing structural changes after head injuries.—*Audrey G. Morgan.*

Bovard, Paul. Correlation of disability with roentgen and clinical findings in silicosis: Part I. *Radiology*, July, 1943, *41*, 11–12.

The author concludes that disability from silicosis cannot be determined accurately by roentgen examination alone, yet serial roentgenograms should be taken as an aid in such determination. A roentgenogram should be made before employing men in occupations in which there is a dust hazard and men should be rejected who have tuberculosis, emphysema or other conditions that might later be confused with silicosis. After a man is employed a record of illnesses, particularly those due to pulmonary conditions should be kept. Routine clinical examinations and roentgenograms of the chest should be made. The roentgen and clinical findings do not run parallel. There may be slight disability with severe changes, and vice versa. A part of the dyspnea in silicosis is due to fibrosis of the alveolus itself and not to nodular fibrosis. If alveolar elasticity can be increased the patient improves. When there is superimposed infection, particularly with tuberculosis, total and permanent disability may be expected. In a series of films there should be roentgen evidence of approaching disability. There seems to be need for closer cooperation between legislators and physicians in determining accurately the degree of disability in silicotics.—*Audrey G. Morgan.*

Hannon, J. W. G. Correlation of disability with roentgen and clinical findings in silicosis: Part II. *Radiology*, July, 1943, *41*, 13–17.

Disability in silicosis is due primarily not to the nodular fibrosis but to thickening of the walls of the alveoli and the associated emphysematous changes with decreased elasticity of the lungs resulting in interference with normal gaseous exchange. These changes occur before any fibrosis can be seen on the roentgenogram. Later, edema of the air sacs and terminal bronchioles and engorgement of the capillaries surrounding them contribute to the disability. The disability must be estimated, therefore, in terms of the decreased function of the lungs rather than by the amount of nodular fibrosis seen on the roentgenogram.

Methods of testing respiratory function are described and illustrated. When a normal person needs more air he gets it chiefly by increasing the depth of respiration. A person with respiratory disability can increase his depth of

respiration only to a very limited extent. When he needs more air he must increase his rate of respiration.—*Audrey G. Morgan.*

Schumacher, Forrest L. Evaluation of disability in low back injuries. *Radiology*, July, 1943, *41*, 18–22.

Disability varies directly with loss or impairment of function. The most common industrial injury is simple muscle or ligamentous strain. Chronic strain is perhaps next in order; then rupture of a muscle or ligament. Any combination of these may occur plus involvement of joints.

Sometimes a diagnosis of sacroiliac sprain is made. This is generally due to old disease and not to the industrial accident. Another frequent mistaken diagnosis is arthritis aggravated by injury.

The end-result in low back injuries is manifested by limitation of motion and loss of strength. There must be some method of calculating these in the given case as compared with normal. Normal flexion and extension combined have a range of 130 degrees; if this is impaired 20 per cent and lateral extension 10 per cent Kessler says the greater impairment, or 20 per cent, should be considered the amount of the disability. If loss of lifting power is 10 per cent he still accepts the larger figure of 20 per cent as the degree of impairment.

McBride breaks up function into its component parts: quickness of action, coordination of movement, strength, security and endurance, to which he adds for industrial purposes safety as a workman and prestige of normal appearance in securing employment. The total of these components is 100 per cent. Each component is considered and its percentage noted; the sum total is the percentage of disability.

Either of these systems furnishes a sound working basis for computing disability.—*Audrey G. Morgan.*

Baker, E. C. Correlation of disability with roentgen findings: the extremities. *Radiology*, July, 1943, *41*, 23–28.

By studying the roentgen findings in large series of cases it may be possible to work out correlations between clinical and roentgen findings on which prognoses can be based. This is a form of consultation which should prove increasingly useful to patients and referring physicians.

Three groups of cases are presented in which prognosis can be based on roentgen findings. In the fracture group tables are given showing what types of fracture carry the most unfavorable prognoses. Another group includes arthritic changes and pathologic conditions such as Charcot's joint which show that the patient has syringomyelia or syphilitic involvement of the spinal cord. There may be healing of bone and joint destruction and partial reorganization of tissue, but disability is permanent. The third group includes soft tissue injuries, including fluid about the joints, bursitis anterior to the patella, sprain fracture with swelling of the soft tissues around it and hemorrhage into the soft tissues. The author makes a special plea for more interest in the roentgen examination of soft tissue pathology on which prognosis may be based.—*Audrey G. Morgan.*

Goldmann, Carl H., and Smith, Stephen J. X-ray appearances of bone in yaws. *Brit. J. Radiol.*, Aug., 1943, *16*, 234–238.

The authors discuss 101 cases of yaws proved clinically in which they made roentgen examinations. The patients were natives of Sierra Leone. The findings are illustrated with roentgenograms. Yaws is very similar to syphilis clinically and the Kahn reaction is positive in the blood. For the purposes of this paper the cases are divided into active and inactive.

The bone changes are most frequent in the tibia and next most frequent in the fibula. The fibula is rarely affected in syphilis. In active yaws the first roentgen signs are in the compact bone tissue, in contrast with syphilis in which they are in the periosteum. Yaws in the spinal column is infrequent and the patient presents the clinical picture of infective spondylitis. The affected vertebra is eburnated. In the clavicle, ribs and os pubis the affection is gummatous. Sequestra do not form, as a rule, and the periosteum is not usually affected. The clinical condition is extraordinarily mild in comparison with the roentgen findings. Specific treatment improves the disability within a few weeks.

The differentiation between syphilis and yaws is of great practical importance, for a soldier with yaws is worth keeping in the Army while one with syphilis is a very doubtful risk. Syphilis may imitate every picture of yaws but it is unusual for syphilis to attack the bone and leave the periosteum unaffected. Acute osteomyelitis must also be excluded. A patient with

the latter disease is very ill while one with yaws may be able to walk about. Yaws may of course be complicated by other infections. Osteitis deformans is quite common in Africa; it should be remembered in making this differentiation that yaws does not form sequestra. The roentgen findings in late yaws are very similar to those of Paget's disease which suggests that Paget's original idea that his disease is caused by a mild chronic infection may be true. Differentiation of tuberculosis from yaws may not be possible on roentgen examination alone. Generally there is much more extensive decalcification in tuberculosis than in yaws. There is a characteristic haziness in the picture of tuberculosis which is lacking in that of yaws. Clinically tuberculosis is a rapidly fatal disease in Sierra Leone while children with yaws normally improve. Joint lesions must sometimes be differentiated from yaws-arthritis. In yaws there is little decalcification and roentgenograms of the adjoining tibiae sometimes make differentiation possible. Avitaminosis is said to present a picture similar to that of yaws but decalcification is prominent and widespread throughout the skeleton. Yaws is frequently associated with avitaminosis.—*Audrey G. Morgan.*

Brocklebank, J. A. The radiological appearances of bone in cases of tropical ulcer. *Brit. J. Radiol.*, Aug., 1943, *16*, 221–224.

A series of cases of tropical ulcer in West African natives accompanied by roentgenological changes in the bones of the leg is discussed and roentgenograms given showing the nature of the bone changes. These tropical ulcers occur chiefly on the feet and lower part of the legs, and the roentgen changes are in the leg bones, chiefly the tibia. In about half the cases there were no bone changes, and the severity of the bone changes, or even their presence, showed no relationship to the size or severity of the ulcers. The earliest roentgen change was a local periostitis which advanced to a local osteoperiostitis and finally a pronounced osteomyelitis often affecting the whole of the diaphysis of the tibia. The epiphyses were not involved in any of the cases. Sequestra are almost always formed early and may involve the whole shaft. It is a striking fact that there is little deterioration of the general health in spite of advanced bone lesions. One man walked in for examination and half of the shaft of the tibia was found sequestrated. In some cases the bones of both legs are involved though there is a history of ulcer of only one leg.

The Kahn test was negative in these cases but it is often hard to make a roentgen differentiation from the bone lesions of yaws or syphilis. Gummatous syphilis shows less periosteal reaction in comparison to the bone destruction than the cases of tropical ulcer. In periostitis caused by *Bacillus coli communis* there are bone changes similar to those of these cases of tropical ulcer. The bacteriology was not studied in these cases.

The true etiology of tropical ulcer is not known so it is impossible to say whether the bone changes are the cause or the result of the ulcers. Possibly a dietetic factor or a sickle-cell lesion may be responsible for both ulcer and bone changes. In some of the cases in the above series it seems probable that the bone changes were caused by direct infection from the ulcers. The experimental production of osteomyelitis is easier when the vascular supply to the bone has been impaired. It is possible that tropical ulcer may impair the blood supply of the underlying bone and facilitate infection, or some general factor may cause such impairment of blood supply.—*Audrey G. Morgan.*

Brailsford, James F. Avascular necrosis of bone. *J. Bone & Joint Surg.*, April, 1943, *25*, 249–260.

Disturbance of the vascularity of bone by trauma, emboli, inflammatory, or neoplastic changes may result in avascular necrosis of the affected bone. Avascular necrosis becomes associated with osteoporosis of the adjacent bone and the phenomena known as osteochondritis, although it is not always a recognizable factor in the latter. Evidence of disturbance of the vascularity of a fragment of bone may be shown in the roentgenogram within six weeks of the application of the causal factor. Brailsford states that if the signs of osteochondritis develop in association with avascular necrosis, the necrotic fragment will be recognizable by its relative density throughout the whole period of reorganization which may be upwards of four years.

The point is stressed in this paper that the clinician should give due attention to the long period of bone plasticity in osteochondritis. Disregard of this is responsible for the deformities caused by stresses and strains on the inadequately immobilized joint surfaces. Avascular

necrotic bone shows a plasticity which persists over a similar period. Brailsford believes that osteochondritis presents a characteristic time table. If the part affected is spared from stresses and strains during plasticity, regeneration is perfect.

He points out that the roentgenographic changes of Legg's disease and those following surgical trauma in reducing congenital dislocation of the femoral head, dislocation of the femoral head due to trauma, fractures of the femoral neck, and displacement of the femoral diaphysis from its capital epiphysis are not identical. They vary from complete restoration to complete destruction of the joint, although vascular necrosis may occur in many of these conditions. Roentgenograms, he asserts, do show evidence of pathological changes in the metaphysis of the upper femur in some cases before disintegration and displacement produce the lesion known as slipped epiphysis. Attention is drawn to the fact that recognition of this roentgenographic finding and prompt institution of protective measures may prevent the displacement and the consequences of avascular necrosis of the epiphysis. In Legg's disease the appearance of fragmentation is seen in the destructive phase, whereas in the case of surgical trauma it occurs in the regenerative phase. In the latter condition, the fragmentation resembles the ossification of the femoral head in hypothyroidism, but the epiphyses will not stand up to normal weight bearing and so are deformed, as are the epiphyses in Legg's disease, the difference being in that in Legg's disease the deformity occurs during disintegration rather than during reorganization.

Osteochondritis dissecans produces symptoms when the fragment becomes necrotic or displaced. The lesion may be recognized roentgenographically several years before this may happen. Temporary retention of calcium by a fragment of bone does not indicate that the fragment is necrotic. It may fuse without any of the secondary changes characteristic of necrotic bone. While avascular necrosis of bone can be detected roentgenographically by the greater density of a fragment which may also show friability associated with decalcification of adjacent bone, nevertheless hypercalcification of bone, Brailsford states, is not in itself an indication of avascular necrosis.

As long as the necrotic bone is present, decalcification and plasticity of adjacent bone will exist. This is an indication that necrotic bone in traumatic cases should be removed as soon as detected, if for any reason the part cannot be efficiently immobilized until complete restoration can be detected roentgenographically.

Brailsford emphasizes the fact that the clinical signs and symptoms of disease usually disappear long before the plasticity of the bone. Treatment must therefore be regulated by the roentgenographic appearances and not by the absence of clinical signs and symptoms. Rest of the affected bone should be enforced as long as the roentgenograms suggest plasticity.—*R. S. Bromer.*

Engel, D. The etiology of the undescended scapula and related syndromes. *J. Bone & Joint Surg.*, July, 1943, *25*, 613–625.

Engel states it is the purpose of this paper to widen the circle of the "bleb diseases" and to show that the undescended scapula and allied conditions are members of the same family.

A short outline of the bleb theory is as follows: Weed described the area membranacea at the roof of the fourth ventricle through which cerebrospinal fluid escapes to form the subarachnoid space. If for some pathological reason —such as the excessive production of spinal fluid, or its deficient reabsorption—or, perhaps in consequence of a primary disunion in the midline, the area membranacea remains unduly patent, cerebrospinal fluid escapes into the subcutis of the adjacent neck region. The subcutaneous blebs so formed spread on the body surface, and on their path exert a deleterious influence by pressure, and provoke an inflammatory reaction. They are driven by physical forces toward areas of least resistance, and are arrested and retained by preformed cavities and pockets, like the orbits or limb buds. It has been shown experimentally by Bagg and Little, and by Bonnevie that these blebs are the direct cause of manifold deformities in animals, such as club-foot, claw-hand, and polydactylism. Deformed second and following generations of mice which had not been irradiated, produced progeny affected, in a high proportion of cases, by the same malformations. The acquired anomalies thus proved to be inheritable. Blebs, such as described by Bagg in his strain of mice, were also observed in human embryos by Bonnevie and were associated with anomalies of fingers and toes.

Engel believes that by classing the three syndromes, namely, Sprengel's deformity, Klippel-Feil syndrome, and symbrachydactylia, among

the bleb diseases, a further group of deformities has been brought nearer to understanding. The evidence given in favor of this view is at the same time a further support of the bleb theory in general. He believes that this theory has a greater scope in the pathology of malformations than is generally known.

Engel's reason for singling out these three syndromes from a larger group is their localization around the shoulder girdle. The Klippel-Feil syndrome is characterized by shortness of the neck caused by abnormalities such as fusion and reduction in the number of the vertebrae, with secondary scoliosis or kyphosis and restricted head-neck movements; low implantation of the hairline; frequently webbed neck caused by stretching of the trapezius; an elevated scapula; torticollis of osseous or muscular origin; disproportion between the length of the extremities and the trunk; and descent of the nipples.

Symbrachydactylia is characterized by shortness and other anomalies of the fingers, combined with syndactylism. It affects principally the upper, and hardly ever the lower, extremities. The nails are often abnormal, and the radius is sometimes missing. The association with undescended scapula, defects of the ribs and clavicle and anomalies of the mamma are very frequent. It is also of great interest that the skin between the arm and thorax is often webbed, a feature frequently seen in bleb diseases.

Engel discusses the arguments in favor of the bleb theory, in which the primary cause of the deformities is an inherent quality in the embryo itself, and points out the arguments against the explanation of the deformities on an exogeneous basis such as pressure by the womb or amnion. One of the strong arguments in favor of the undescended scapula being one of the bleb diseases is the fact that it constitutes one of the signs of dysostosis multiplex which belongs to the bleb disease group. In a high proportion of these cases an undescended scapula was recorded and explained by the bleb mechanism.

The 2 cases recorded in the literature by Horwitz and Bizarro are the only ones which so far have come to Engel's attention as giving unmistakable direct evidence of a "bleb" in the neck region. If it is considered that the cases of undescended scapula are brought to the surgeon usually several months or years after birth, it will be understood that "lumps" in the neck of transitory character are frequently overlooked, and if observed, they are very likely to be mistaken for a cephalhematoma. The question of whether any direct sign of a bleb in the neck region of patients affected by undescended scapula has ever been reported can thus be answered in the affirmative.—*R. S. Bromer.*

Hartley, J. Blair. "Stress" or "fatigue" fractures of bone. *Brit. J. Radiol.*, Sept., 1943, *16*, 255–262.

Stress or fatigue fracture of bone is not very well understood though march foot has been recognized and reported since 1855. The fatigue fractures considered here are due to the same causes as march foot, but they occur most frequently in the tibia, particularly in the upper third. A strict differentiation must be made between these fractures and pseudofractures occurring at Looser's transformation zones, or pathological fractures occurring in any disease of bone, such as Paget's disease, diseases due to avitaminosis or bone tumors. A table is given showing the differences between stress fractures and pseudofractures.

The first and outstanding symptom is pain which almost always subsides when adequate rest is given. It is not sufficient to put a soldier on light duty or excuse him for a little while; prolonged rest from weight bearing is necessary and it may be necessary to supplement this with plaster. The characteristic roentgen finding is callus formation. These calluses generally appear at points where there is an overload, as for instance in the posteromedian aspect of the tibia where the "axis of vertical stress" through the internal condyle cuts the cortex. In some cases a crack or definite fracture line can be demonstrated, usually about three weeks after the onset of symptoms. Pathological fractures in bone tumor occur relatively late. The findings may be bilateral and symmetrical or bilateral and asymmetrical.

Rapid organization of callus, the formation of a zone of sclerosis and rapid healing of the fracture are of good prognosis and generally occur if adequate rest is given. If a transverse zone of osteoporosis extending across the bone develops the prognosis is bad. It shows that overstress has persisted too long after bone fatigue began and recovery will be slow, taking months instead of weeks, and there is danger of complete fracture.

Some authors believe the condition is due to nutritional deficiency but the author believes that the chief if not the only factor is a dispro-

portion between what is required of the bone and its inherent capacity to bear stress. He believes that now that the younger age groups are being called to the fighting forces and as a result of high-pressure training of Commando units and possibly of parachute training many more cases will appear and much will be learned about the condition.

The treatment is rest. Early cases of bone neuralgia require only a few day's rest without immobilization. The more severe cases with periostitis or actual bone fatigue require more prolonged rest with immobilization and more gradual resumption of weight bearing. Very severe cases will require immobilization in plaster for weeks or months and very gradual return to normal weight bearing.

Mistaken diagnosis may lead to recurrence or involvement of the opposite leg or complete fracture of tibia and fibula, or to unnecessary operation for suspected bone infection and even to threatened amputation. Correct treatment is simple and always brings about recovery. The condition may be caused by Army service and lead to claims for compensation.

The author suggests the use of radioactive indicators in detecting any deviation from normal replacement in fatigue fractures and in determining whether bone exhaustion disturbs or delays normal replacement.—*A. G. Morgan.*

Sweet, Howard E., and Kisner, Wendell H. March fractures. *J. Bone & Joint Surg.*, Jan., 1943, *25*, 188–192.

The authors agree with Meyerding and Pollock that march fractures are the result of overloading of a foot already weakened functionally and anatomically. The bone lesions in their series of cases in the Army service were incurred while the patients were undergoing strenuous marches with considerable overloading of feet that were probably already weakened.

The earliest change noted in the roentgenograms of their patients was a thin, transverse, hair-line fracture through the cortex of the metatarsal bone. At times this was so faint that it was necessary to use a reading glass to visualize the fracture. They found it not uncommon in the early stages of the lesions to find a normal-appearing bone in the roentgenograms. Later ones showed a crack transverse fracture with beginning callus formation. Still later roentgenograms showed a spindle-shaped mass of callus surrounding the fracture. Occasionally, in advanced cases, there was only a mass of callus with no fracture line visible.

A history of insidious pain in the foot, which is progressive, and is relieved by rest, and within twelve to twenty-four hours is associated with edema of the dorsum of the foot should suggest march fracture. There is tenderness over the involved bone.

The treatment followed in their cases was immobilization of the foot in a plaster boot for a period of four to eight weeks, depending upon the roentgenographic finding of adequate callus formation. Following removal of the plaster boot, the patient was given one to two weeks of rest and physiotherapy and was then returned to full military duty.—*R. S. Bromer.*

Childress, H. M. Fracture of a bipartite carpal navicular. *J. Bone & Joint Surg.*, April, 1943, *25*, 446–447.

Childress reports a case of a fracture of a bipartite carpal navicular. The roentgenograms of the right wrist were made in four positions. One view was interpreted as an old fracture of the carpal navicular with traumatic arthritis between the fragments. Also, the distal portion appeared to be rotated 90 degrees clockwise. Because of these unusual findings, a roentgenogram was made of the left wrist of the patient and the left navicular was found to be bipartite. Ten years previously the patient had injured his wrist in much the same fashion as the recent trauma and the original roentgenograms were obtained. They showed the right navicular to be bipartite, and its distal fragment to be fractured. The abnormal appearance of the distal portion in the recent roentgenogram was due to malunion, and not to rotation as was first believed.

This case is reported because of its rarity and because it illustrates well the value of checking unusual bone findings in an extremity with roentgenograms of the opposite normal one.—*R. S. Bromer.*